

METAL

Horror

ZIRCONIUM

*costs less today
than you may think!*

A recently-published article in *Metal Progress** provided an interesting economic appraisal of zirconium and stainless steel in nuclear power reactors. The article covered five power-producing thermal reactors spanning the entire range of fuel enrichment. To supplement these facts, we would like to add these key points about zirconium.

Check TODAY'S Zirconium prices

In our discussions with designers and builders of nuclear reactors, we still find some who think of zirconium prices in terms of \$100 per pound. Actually, high quality zirconium strip and rod are available through Mallory-Sharon at \$11 to \$14 per pound. Even tubing—always more expensive in any metal—is frequently priced at under \$30 per pound.

What is the break-even point?

In four of the reactors discussed in

the article, the break-even price for fuel cladding material ranged from \$44 to \$104 per pound. On permanent parts, the range was from \$109 to \$842 per pound. Thus zirconium, at present prices, offers important economic advantages over stainless steel.

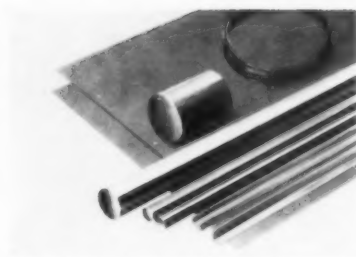
Future price trend important

The break-even point is not necessarily a static one. Future trends in prices of both zirconium and stainless steel must be taken into account.

For example:

1. As zirconium production and use increases, price of mill products will be reduced still further.
2. Increases in stainless steel prices will raise the break-even point.

Thus, for the future, certain applications which may be borderline cases at present, will most surely show definite economic advantages for zirconium.



Typical mill shapes produced in zirconium by Mallory-Sharon include rounds, bars, billets, wire, sheet, strip, plate, tubing.

Advantages of Zr for refueling

The declining price trend of zirconium has a vital bearing on cost of future refueling operations. Even where zirconium's present economic advantage may be close to the borderline, future price reductions will substantially increase this advantage 1½ to 2 years from now.

Use of natural uranium a key factor

Because of zirconium's low neutron-absorbing cross-section, uranium of lower enrichment may be employed. This further adds to zirconium's economic advantages through resulting savings in fuel costs.

For pricing assistance...

on zirconium for either fuel cladding or permanent parts, call on Mallory-Sharon. As the only integrated producer of zirconium, we are in a position to render valuable help on pricing your designs or bill of materials—as well as providing lowest prices and highest quality for all types of zirconium mill shapes.



Careful quality control of zirconium tubing and other mill shapes is a continuous top-priority assignment at Mallory-Sharon.

*"An Economic Appraisal of Stainless Steel and Zirconium in Nuclear Power Reactors," appearing in *Metal Progress*, February, 1959. WRITE MALLORY-SHARON for free reprint!

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Metal Progress

September 1959 Volume 76, No. 3

Cover: Another winner (second prize) in A.S.M.'s annual competition at Cleveland Institute of Art is this month's design by HARVEY KLINEMAN based on alchemical symbols.



Steelmaking on the Move

Potential for Oxygen in Steelmaking, Special Report by E. C. Wright.....101

Companies using the oxygen converter process and those experimenting with oxygen in blast furnace and openhearth report economies and increased production rates. Future need for more steel capacity at reasonable cost is expected to spark a boom in oxygen steelmaking techniques. (D-general, D-10; O)

Ultrasonic Vibrations Refine Grain Size, by D. H. Lane, J. W. Cunningham and W. A. Tiller.....108

Vibration during consumable-electrode melting refines ingot grain structure and prevents segregation. Secret of the technique is low-loss transmission of sound energy through the bottom of the mold. Several 12-in. diameter ingots have been made in which ultrasonic energy was applied. (C5h, 1-74; Fe-a)

Vacuum Degassing in Ladle . . . a New Technique in Steelmaking.....111

Hydrogen and other gases are removed from molten steel while it is in the ladle. By purging with helium while the vacuum is being drawn, hydrogen is reduced to less than 2 ppm. in about 15 min. This new technique permits steel from one heat to be poured into several ingots. (D9m, 1-73)

Radio-Isotopes and Soviet Steel, a Report From the U.S.S.R. by Arthur B. Tesmen.....115

The Russians have evolved many methods for studying steelmaking processes with radio-isotopes. Blast furnace techniques which have been devised include ways to measure stock feeds, wear on furnace bottoms and charge levels. In the refining process, much work has been done on dephosphorization, desulphurization, scrap melting, and slag formation. (D-general, 1-59)

Engineering Articles

Austenitic "Cold Working" for Ultra High Strength,

by D. J. Schmatz, J. C. Schyne and V. F. Zackay..... 66

Need for materials with higher strength-to-weight ratio has motivated the search for new heat treating processes for steels. Key to a technique studied at Ford is plastic deformation in the austenitic "bay" of the TTT-diagram between pearlite and bainite, then quenching to prevent transformation to nonmartensitic products. (J26p, Q27; AY)

Quality Control With Eddy Current Techniques, by C. E. Quinn..... 70

A new inspection instrument, the Laminagage, readily measures the thickness of thin gages and plates. Also useful for locating fine cracks, this versatile tester employs plug-in coils and several types of probes. (S12h, S14h, 1-53)

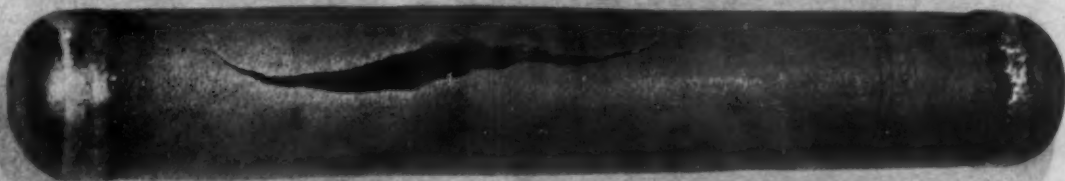
Vapor-Phase Plating With Molybdenum and Tungsten, by H. W. Schultze..... 74

Deposits of metals or their refractory compounds are produced from chlorides and carbonyls of molybdenum and tungsten at temperatures considerably below the melting point of the metals. Coatings can be produced on a variety of metals: ceramics, glass, refractories and graphite. Interest in the process is spurred by today's technological needs and commercial availability of the plating chemicals. (L25; Mo, W)

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*The coding symbols refer to the ASM-SLA Metallurgical Literature Classification, International (Second) Edition, 1958

Centrifugally cast Thermalloy tube burst at 77,500 psi



Wrought tube burst at 70,100 psi

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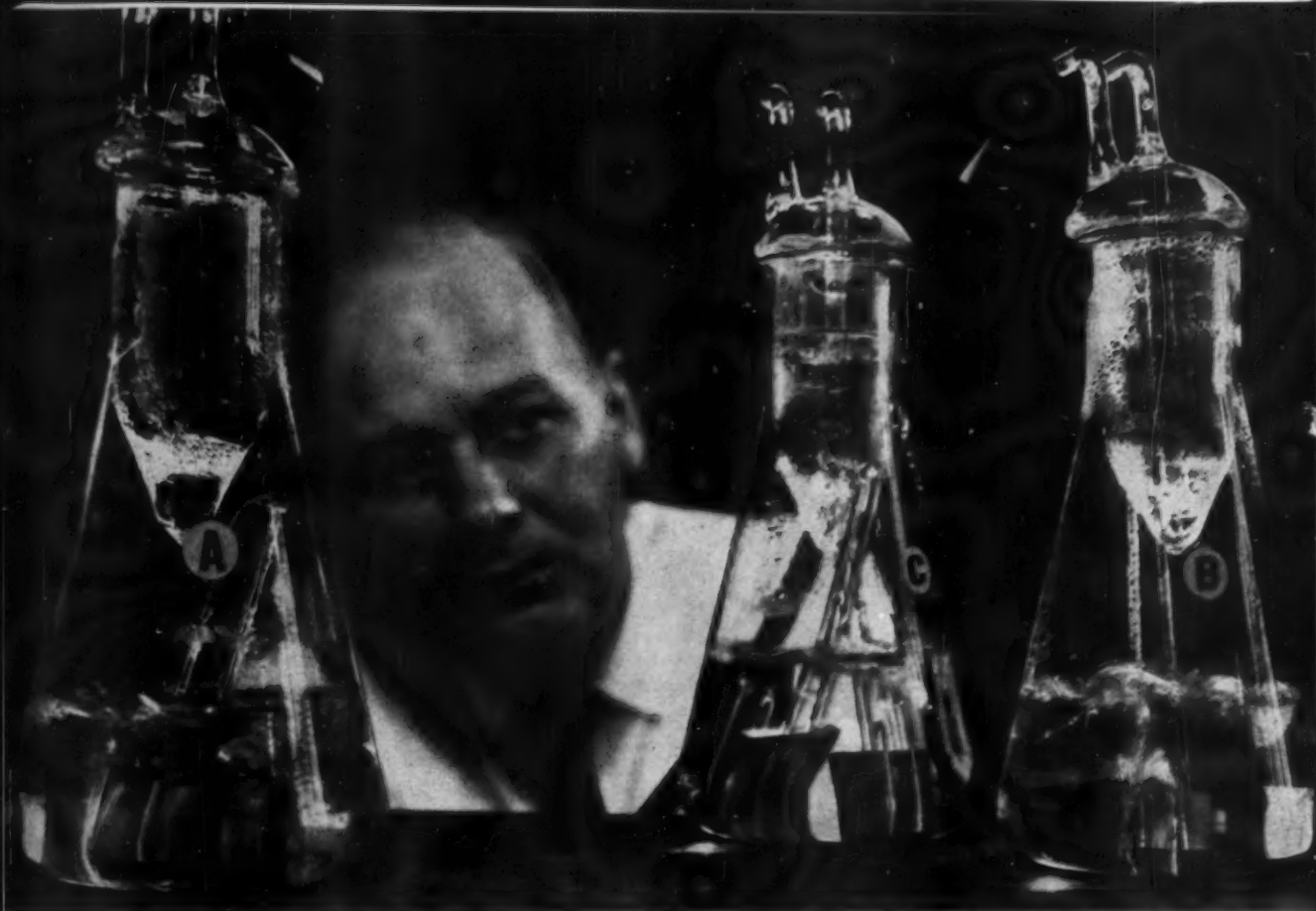
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Metal Progress

Mechanical Testing With a 3000° F. Radiant Furnace , by J. K. Hoy.....	81
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"How Jessop Tests Stainless Steel in Boiling Nitric Acid"

L. W. Cooper, Chief Metallurgist

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Here, boiling nitric acid is used to evaluate the corrosion resistance of Jessop stainless steel plate.



Checking the grain size of tool steel, this Jessop metallurgist uses a microscope with a camera attachment.

VMA 6767

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Press Breaks...

PRESS BREAKS this month may well be a series of items taken from the Editor-in-Chief's note book and letters to staff members during the first part of his recent European trip. This was strictly a vacation, but you know the adage about the busman's holiday. Mr. Thum evidently carries with him a metallurgical viewpoint:

Small World Department

While standing on the steps of the Vatican Museum who should appear but Dick Wiley, past chairman of the Washington Chapter. He and his wife and daughter were on a tour with 60 or 70 others, a group organized by Naval Ordnance Research. They were on their own that day, else we might have had an overseas chapter meeting on the spot; it would not have disturbed anybody, since there were at least 10,000 tourists in the Sistine Chapel that morning.

At the Cathedral in Pisa was a handsome policeman with an armband lettered "English", the very spit and image of a good ASM'er and equally as suave and helpful as his double Peter Kostig, long at Watertown Arsenal but now division director at the Office of Ordnance Research (U. S. Army) at Durham, N. C. The two are not related.

Metallurgical Notes — Cuprum Division

There was evidently a shortage of metal in Rome in 1670 when the enormous bronze canopy was erected above the papal altar at St. Peter's. The heavy metal panels lining the great dome of the Pantheon were removed and re-cast — possibly defensible because the Pantheon was originally a pagan temple, rebuilt by the Emperor Hadrian in the 2nd century A.D. The guide didn't know where Hadrian stole the bronze in the first place.

"The Gates of Paradise" are, fittingly enough, of bronze. So Michelangelo characterized the east doors to the ancient Baptistry, just in front of the Cathedral in Florence. Each door has five scenes from the old testament, designed by Lorenzo Ghiberti, an eminent goldsmith of the mid-15th century. One might guess that these ten elements were cast separately and fitted into a main frame which in turn was bolted to a stout oak skeleton, although there is only the slightest suggestion here and there of any joint. A similar bronze panel, on exhibit in one of the many museums, was evidently a slush casting, although the coring for undercuts must have been intricate in the extreme. The fineness of the surfaces, the delicate tracery in the backgrounds, and the paper-thin leaves on the decorative foliage on the Baptistry doors indicate that an enormous amount of hand work was necessary to finish each casting. (The contemporary bronze doors at the Cathedral in Pisa were made in many small pieces. Not only the frame but also the panels themselves show clearly many joints and pins.)

I must find someone who knows something about these exquisite techniques and get him to write an article for *Metal Progress*.

Hands-Across-the-Sea Division

Prominent posters observed in Naples had this big headline:
Sciopero
dei Metallurgici!

The "dei" led me to hope that the Italians had at long last deified metallurgists, but a friend interpreted it to mean a call for a mass-meeting of striking steelworkers. Messrs. McDonald of the Steelworkers' Union and Cooper of the American steelmaking industry might take note that they have not been alone in their economic troubles! (Continued on p. 6)

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Press Breaks . . .

Metallurgical Note — Plumbum Division

The small lead pipes which supplied some citizens of Herculaneum with water are still in operating condition. This city was engulfed by a mudslide from the Vesuvius eruption of 79 A.D. The pipe was made of lead sheet (possibly cast on a flat stone slab) trimmed, bent and soldered longitudinally. Extrusion is modern; it had to wait the construction of powerful hydraulic machinery.

Metallurgical Note — Argentum Division

In the treasure room of the Duomo, the Cathedral at Florence, is a silver altar made during two centuries by the best of the city's silver-smiths (none better anywhere, anytime). Fortunately it can be examined closely. It is made up of many deeply embossed panels of silver sheet, perhaps 16 in. square, representing various scenes in the life of John the Baptist, the city's patron saint. A photograph of one of these panels is reproduced; it will be seen that each of them is fitted between highly ornamental mullions and pilasters, the latter containing niches with small statues. Literally thousands of such items, each one a gem, are soldered and pinned together and to the underlying frame, joined so closely as almost to defy detection.

Note on Motor Cars

Up Italy, from Naples to Rome to Florence to Riviera there was not a single automobile graveyard to be seen, even though the roads were crowded with everything from motor scooters to trucks with double trailers. From Cannes to Grenoble to Vézelay in France, billboards appeared and two small auto dumps were counted. You pass (and are passed by) many vintage Renaults and Citroens with boxy bodies like the Model T Ford. Undoubtedly autos are better cared for than in America — even the trucks are clean and have good paint jobs.

Rail Transportation Note

Judging from the dilapidated condition of the station buildings and railway right-of-way, the branch lines in Burgundy are suffering as much from automobile and truck competition as they are in the United States. The antiquated Pullman cars (next step above First Class) such as the famed "Golden Arrow", Paris to London, suggest one reason for this. However, the Rome-to-Milan express leaves nothing to be desired in speed and comfort.



Detail of the Silver Altar: John the Baptist in the Desert

Metal Progress

PUBLISHED BY AMERICAN SOCIETY FOR METALS
METALS PARK, NOVELTY, OHIO



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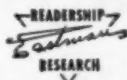
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METALS PARK, NOVELTY, OHIO, JORDAN 4-2271

METAL PROGRESS is published monthly by the AMERICAN SOCIETY FOR METALS. Printed by Kable Printing Co., Mt. Morris, Ill.

Subscription \$9.00 a year in U. S. and Canada; foreign \$15.00. Single copies \$1.50; special issues \$3.00. Requests for change in address should include old address of the subscriber; missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of issue. No claims allowed to overseas subscribers.

The AMERICAN SOCIETY FOR METALS is not responsible for statements or opinions in this publication.



Metal Progress is available on microfilm from University Microfilms, Ann Arbor, Mich.

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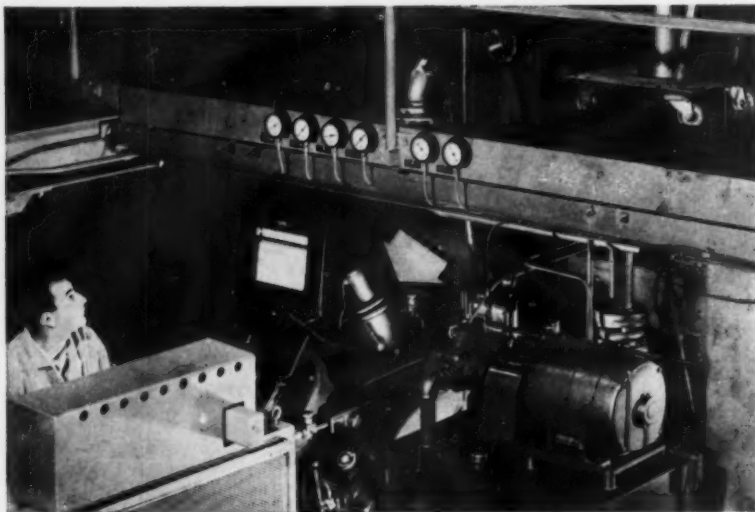
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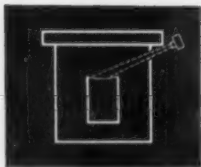


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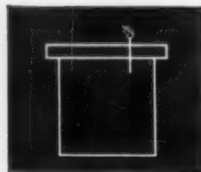


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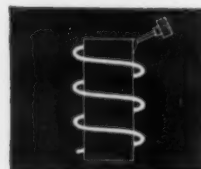


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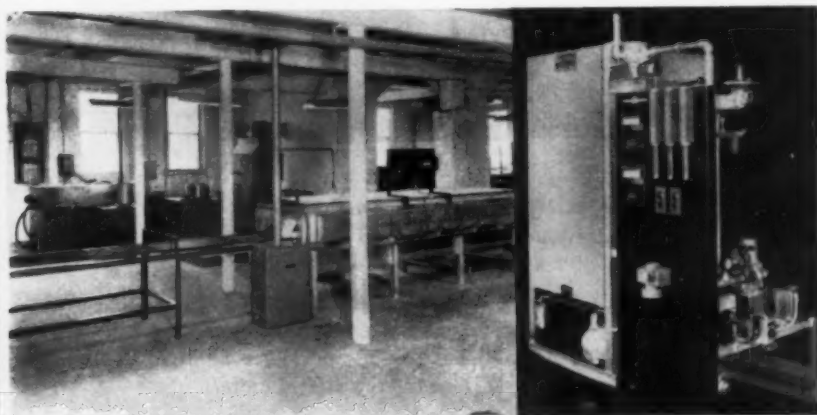
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Medium temperature application of silicon carbide elements "across-the-line" eliminates transformers—simplifies furnace installations

Compact, simply controlled electric furnaces, connected "across-the-line" on 115 or 230-volt power distribution systems, offer new opportunities for economical heat treatment under favorable conditions in the medium temperature range. Higher temperatures are possible for certain operations.

Long-life GLOBAR Delta elements that increase in resistance at a slow, uniform rate make on-the-line operation of these elements practical and economical. Equipment cost is kept low because tap transformer control is not required.



WIRE ANNEALING FURNACES at Electric Wire Company of Northampton, Mass., use GLOBAR elements across a 220 volt line and operate at 1800° to 2250° F. GLOBAR silicon carbide elements installed over 18 months ago are still in use.

LATEST TYPE "IGL" Hayes Protective Atmosphere Generator, uses 12 GLOBAR Delta elements on 230-volt supply. Customers report only slight increase in resistance after extended service.

New advance increases ECONOMIC ADVANTAGES OF ELECTRIC HEAT

Electric heating is meeting the growing demand of industry today. The adaptability, versatility and dependability of long-life silicon carbide elements, the ease of replacement without a complete shutdown, and minimum maintenance are vitally important to the operator.

Electric heating is economically attractive for a wide range of processing operations. Simple, low-cost installations, without expensive transformers, are easily controlled by an automatic pyrometer and magnetic contactor up to 2000° F, and favorable operating requirements may permit higher temperatures. Applications should be carefully evaluated and individually engineered. Electric heating efficiency is high, you don't pay for Btu's that go up the stack. Exhaust and fuel storage facilities are unnecessary. It is clean, safe and quiet with no fire or explosion hazard. Compact GLOBAR equipped furnaces may be located anywhere in a production line. Product quality is improved and rejects are reduced.

Consideration of all factors usually shows savings that may not be apparent in a simple comparison of fuel costs.

Typical applications for GLOBAR Delta elements include Ceramic firing, heat treatment, forging, sintering, brazing, annealing, melting, assaying, roasting and laboratory control and testing.



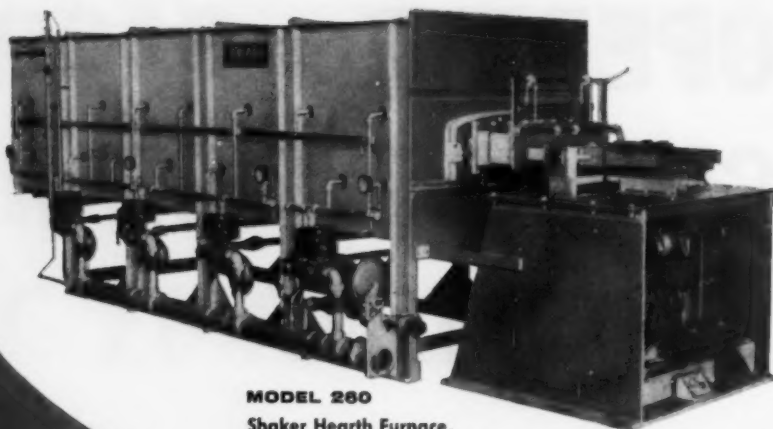
Find out how your operation can profit by using GLOBAR Delta silicon carbide heating elements. Your furnace builder can supply you with full details. The Carborundum Company, Refractories Division, Globar Plant, Dept. MP99, Niagara Falls, New York.

CARBORUNDUM

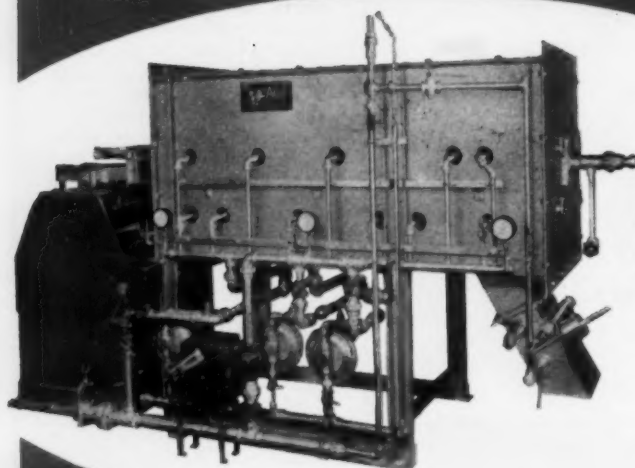
Registered Trade Mark

HEAT
TREAT
SMALL
PARTS
BEST
with

AGF'S SHAKER HEARTH FURNACES



MODEL 260
Shaker Hearth Furnace,
with a production
capacity of 800 lbs. per hour.



MODEL 236-A
Shaker Hearth Furnace,
with a production capacity of
approximately
150 lbs. per hour.



VERSATILE Complete atmosphere control for heat treating from pen points to forgings, *IN THE SAME FURNACE.*

SIMPLE Complicated maintenance problems are eliminated by the unique method of work conveyance . . . A reciprocating hearth plus a simple mechanical drive.

EFFICIENT No conveyor to drag heat from furnace . . . A **CONTINUOUS FURNACE** for automatic or manual feeding.

FULL MUFFLE CONSTRUCTION Provides exact control of processing atmosphere . . . Many small burners, in multiple control zones, heat the muffle uniformly.

Shaker Hearths are available with capacities from 25 lbs. per hour to 800 lbs. per hour.

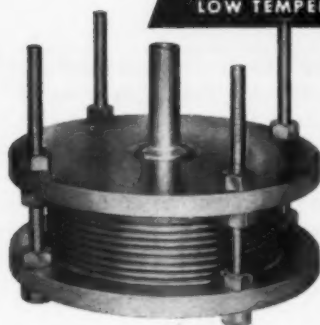
Send for complete data and specification sheets on these and all of the other many "QUALITY BUILT" AGF furnaces for all specific and diversified uses.



AMERICAN GAS FURNACE CO.

1004 LAFAYETTE STREET — ELIZABETH 4, N. J.

**brazed
successfully
with**



This vacuum bellows is part of the liquid target assembly located on the business end of the linear accelerator developed by Stanford University. The bellows is .0106" brass, joined to half-inch-thick Muntz metal flanges. This is a difficult brazing job at best—being done successfully at Stanford University, using Silvaloy 45. Heating is by torch and carbon block. Needless to say, despite the technical difficulties of this job, only a perfect, strong vacuum-tight joint is acceptable.

For this reason, technicians at Stanford University use Silvaloy 45 and Deoxo Flux for their reliable quality and consistent performance.

Silvaloy brazing alloys and fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call your nearest Silvaloy distributor for information or technical assistance.

AMERICAN PLATINUM & SILVER DIVISION
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SILVALOY
LOW TEMPERATURE SILVER BRAZING ALLOY

STANFORD UNIVERSITY

The philosophy of engineering education at Stanford is to provide each man, in so far as possible, with the training that will best fit him to meet life objectives which he himself chooses.



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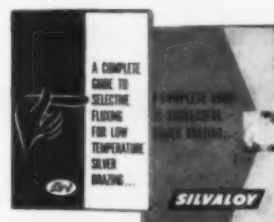
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Two complete reference manuals for low-temperature silver brazing and fluxing are available upon request. Send for either one or both. ★ ★ ★ ★ ★ ★ ★

Republic's **CENTURY 100** SERIES of

High Strength, Stress Relieved, Cold Finished Steel Bars

What Is The CENTURY SERIES? A family of five grades of cold finished, specially processed, stress relieved bars having a minimum yield strength of 100,000 psi. Available from Republic in C-1144, C-1141, C-1151, C-1050, C-1045.

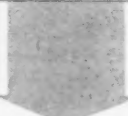

Why a CENTURY SERIES? To meet the needs of steel parts producers requiring high strength with varying degrees of machinability. The CENTURY SERIES assures dimensional stability with excellent machinability, provides high mechanical properties in a range of chemistries.

Republic's overall policy has always been to suggest the least expensive grade of steel that will adequately meet the mechanical requirements of the application and the degree of machinability desired.

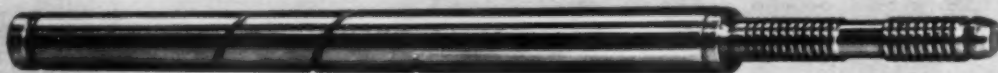
C-1144, for example, would be the proper choice for a part requiring high strength combined with maximum machinability. However, it may not be the best or most economical selection for parts on which machinability is not of prime importance.

Republic's CENTURY SERIES makes it possible to achieve considerable savings by selecting the grade best suited to a specific requirement. Where maximum

machinability is not required a lower sulphur grade, such as C-1141 or C-1151, can be considered. If machinability is a minor factor, C-1050 or C-1045 may be considered. As sulphur decreases, toughness and resistance to shock increase. Therefore, it is frequently possible to obtain a better strength/toughness ratio at lower cost by using one of the lower sulphur steels as indicated on the chart.

GRADE	ANALYSIS EXTRA	BEST COMBINATION OF STRENGTH & TOUGHNESS	MACHINABILITY
C-1144	\$1.35		
C-1141	1.10		
C-1151	.70		
C-1050	.15		
& C-1045			

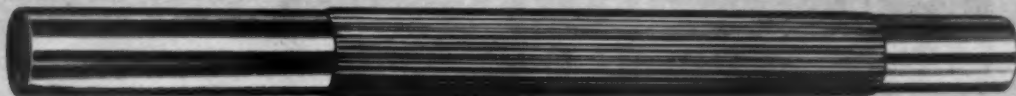
Which Grade Is Best For Your Production? Republic offers the services of expert metallurgists—field, mill, and laboratory—and machining specialists to work directly with your personnel in selection, application, and processing of the right grade for your particular application.



CENTURY SERIES C-1144 Distributor Shaft



CENTURY SERIES C-1141 Hoist Support Shaft



CENTURY SERIES C-1151 Electric Motor Shaft



CENTURY SERIES C-1050 Axle



CENTURY SERIES C-1045 Shaft



Want More Facts? This FREE BOOK provides the basic facts you need to determine where Republic's CENTURY SERIES may help you save time and money in the production of steel parts. Mail the coupon for your copy.

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International's MgO
has the purity others
lack because it's...

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Disappointed with conventional magnesium oxides? Then try International's. It's the only MgO produced by thermal decomposition. And the difference is amazing! Electrically furnaceed, this MgO has achieved the highest resistivity and refractory properties of any commercially available magnesium oxide.

You'll find International MgO relatively low in cost. Now improved production facilities are geared to produce any quantity you need.

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Here's how IMC does it!

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Magnesium Chloride $MgCl_2$
(Contained in sea water,
well brine, bittern.)

+
Lime CaO
(Contained in dolomite,
sea shells, etc.)

↓
Magnesium Hydroxide $Mg(OH)_2$ + heat

↓
Magnesium Oxide MgO

INTERNATIONAL'S UNPARALLELED PROCESS

Magnesium Chloride
 $MgCl_2$ + heat

↓
Magnesium Oxide + Hydrochloric Acid
 MgO HCl

↓ heat → MgO

And here's the result!

MgO	99.5%	Cl	0.03	Density	75 lbs./cu. ft.
S_2O_3	Nil	CaO	0.05	Low Boron, too,	
SO_2	0.03	Fe_2O_3	0.05	upon request!	

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for every answer

...there was a problem

Often when you know where to look for the answer, the problem is half solved. Take the exciting, ever-broadening field of nondestructive testing. Here there are all kinds of answers, because there were -- and are -- all kinds of problems. In this field Magnaflux Corporation is often called "The House of Answers" -- for problems like these:

If you are a materials engineer

You may want to know that the material you select for specific characteristics really has those characteristics when fabricated. Or, can you use a less expensive material safely? Can you be sure that your materials will be free of any defects that matter?

If you are a design engineer

You may want accurate stress and load analysis. You may also want to specify a positive way to test your pilot and production models.

If you are a manufacturing engineer

Your problem may be process control -- not shooting for perfection, just reliable, consistent quality. You'll need a system fast enough to keep up with production and that fits into the rest of your set up.

If you are a plant engineer

Your problem may be how to test for cracked parts during preventive maintenance -- or in plant layout, how you can place the test equipment that will do the desired job most efficiently.

For these and many other nondestructive testing problems

MAGNAFLUX is often called

"THE HOUSE OF ANSWERS"

Magnaflux Corporation is a company devoting its entire effort to the systems and equipment for nondestructive testing used by more industries for more testing operations than all others combined.

The Magnaflux Field Engineers and the Engineering and Research staffs back of them have built their careers on finding the right answers to nondestructive testing problems. They are true specialists who take all factors into consideration in helping you find the test system that will solve your problem. Very often you will find the Magnaflux men already have or can develop the exact answer you are looking for, or they usually know who has the answer and will direct you to it.

The following three pages cover some of the major Magnaflux Test Systems and show why so many of today's nondestructive test problems can be solved by one or another of these systems.

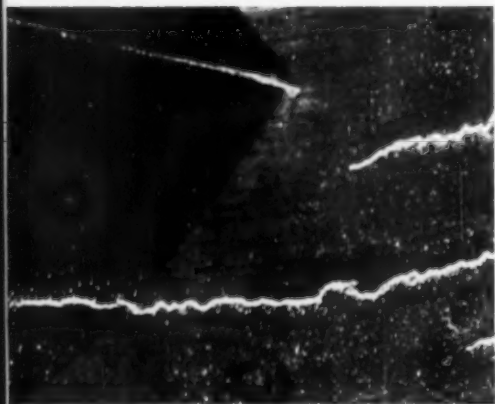


**MAGNAFLUX
CORPORATION**
Chicago 31, Illinois

the answer to your nondestructive testing

MAGNAFLUX® and MAGNAGLO®

most used test for magnetic metals



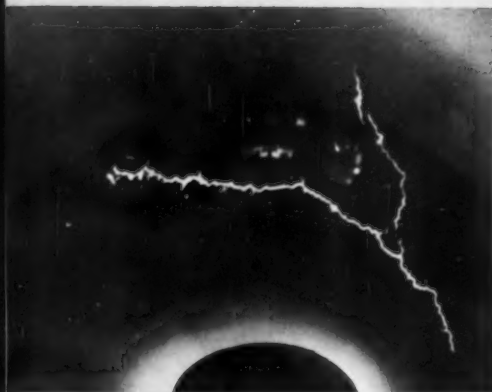
Inspection with Magnaglo shows otherwise invisible fatigue cracks in forged part.

By far the most common crackfinders used on magnetic metals for critical service, Magnaflux and Magnaglo use magnetic particles and controlled magnetic fields to find all cracks, inclusions or other defects at or close to the surface. Sensitivity is adjustable to find either defects as small as a few millionths of an inch or only the grosser ones.

Magnaflux and Magnaglo will find some types of defects that other tests will overlook. They mark defects right on the part. Magnaglo uses fluorescent materials and high intensity black light. Speed of testing is governed solely by production needs, on parts weighing from fractions of ounces to many tons. Fully automatic processing is often provided with the inspector merely "monitoring" parts as they pass through the machine. Cost per part tested is usually even less than for visual inspection alone, and many times more accurate.

ZYGLO® and ZYGLO-PENTREX®

**most used test for nonmagnetic materials -
fluorescent penetrant, black light.**



Zyglo and Zyglo-Pentrex use capillary forces to find cracks—or any other defects open to the surface—in such materials as aluminum, titanium, magnesium, plastics, glass and others. They may be used successfully on rough surfaces where ordinary visual inspection is hard or impossible. All defects are marked directly on the part. Recent improvements have increased maximum sensitivity beyond that of *any other method* in finding and defining certain defects. Near-absolute reliability is assured in leak tests. Adjustable sensitivity for any requirement prevents "over-inspection" and needless rejection. Engineered systems can be full automated.

At any test rate, cost is low; on volume production cost per piece is negligible.

Zyglo reveals and marks serious cracks in stainless steel part.

problems may be here

MAGNATEST®

Eddy current and magnetic measurement instruments evaluate properties of metals, detect variations, etc.

Magnatest instruments provide an almost magic evaluation of many properties within conductive materials by means of induced eddy currents or magnetic fields that "explore" the part or material.

New uses for Magnatest instruments are being discovered continuously, with no limit yet in sight. Some of the purposes for which these units are now supplying precise measurement or evaluation include:

- Measurement of electrical conductivity in absolute units (see illustration). Used to determine material alloy, hardness, heat treat uniformity . . . for sorting of mixed nonmagnetic metals, checking aging of aluminum alloys, detection of fire damage by measuring changes in conductivity, etc.



Magnatest FM-110 Transistorized Conductivity Meter, as used to sort copper billets according to conductivity, prior to machining.

(Photo courtesy Ampco Metal, Inc., Milwaukee)

- Testing nonmagnetic rod, tube and wire at mill speeds to detect laps, seams, inclusions, voids and other defects . . . with automation and recording if desired. (See illustration)
- Precision measurement of DC magnetic fields in geophysics, magnetic investigations, military uses and nondestructive testing of nonmagnetic metals and other related functions.
- Measurement of coercive force for steel property evaluation, for relay and transformer steel lamination stock, etc.
- Rapid, accurate determination of the moduli of elasticity, shear, Poisson's Ratio, and the damping factor of practically any solid materials.

Magnatest instruments for many other applications are also now in use in some of the fastest growing, broadest range fields of nondestructive testing. Magnaflux is the exclusive U.S. representative, using principles developed by Institute Dr. Foerster, Germany. More than 25 different Magnatest instruments are now available through Magnaflux Corporation.



Magnatest FW-400 Rod, Tube and Wire Testing Unit as set up for production inspection of copper tubing at mill speeds.

(Photo courtesy of Wolverine Tube Co., Detroit)

MAGNAFLUX CORPORATION



SONIZON®

Ultrasonic instruments use sound you cannot hear to measure thicknesses you cannot see—or to find hidden defects.

Sonizon SO-200 portable, direct-reading type instrument used here to measure pipe wall thickness.



Sometimes called "a micrometer with only one arm", Magnaflux Sonizon measures thicknesses from one side as quickly as a crystal probe can be moved over the surface. Sonizon instantly detects thin (or corroded) spots in tank walls; in cast, formed, welded or ground shapes; it also reveals defects deep below the surface including laminations and lack of bond. Instruments are available in a unique portable direct reading type (see illustration) and the oscilloscope type.

SPOTCHECK®

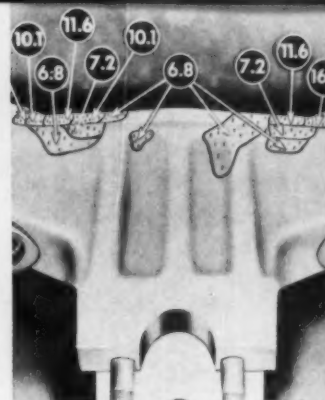
low-cost, fire-safe dye penetrant in spray-on cans

On metal, plastic or other solid materials, Spotcheck provides a low-cost dependable test for medium to large, but still nonvisible, open-to-the-surface defects. Self-contained, pressurized spray cans offer the easy convenient means for handling and applying, or also in bulk. All materials are available in new nonflammable or high-flash formulas.

STRESSCOAT®

Spray-on brittle coating saves time and cost. Gives overall stress analysis.

Stresscoat applied to prototype aluminum truck beam saddle shows operating stresses and concentration points.



Stresscoat determines stress concentration and measures values in simple or complex shapes, in static or dynamic testing. It predicts where parts would fail, so that they can be correctly designed not to fail in service. This makes possible better products that are lighter, stronger, less expensive to produce and less wasteful of material. Stresscoat is used at all stages—from laboratory tests, through pilot models to production units to be sure stresses remain within desired limits. With new ceramic Stresscoat, parts can be immersed in oil or tested at temperatures to 600° F.



Spotcheck in-place test for aircraft landing wheel shows crack that is prelude to failure.

Your Testing Problem is "Different?"

—Tell Us About It

The applications, uses and answers possible with Magnaflux Test Systems have been barely touched upon in these pages. For lack of room, whole systems have been left out. For instance:

STATIFLUX® . . . electrified particle testing for fired ceramics, glass, porcelain enamel, plastics and other nonconductors . . . with constantly growing use in electronics and missile applications.

PARTEK® . . . filtered particle testing for ceramics and nonporous solids to reveal handling, forming and drying cracks in unfired clay bodies before kiln time is wasted on defective ones.

THERMOGRAPHIC TEST OF HONEYCOMBS . . . Bondcheck is a new fast test for proper bond and integrity in metallic honeycomb sandwiches and certain welded structures, widely useful in aircraft construction, among other applications.

INSPECTION SERVICE

In addition, Magnaflux Corporation maintains its own nationwide Commercial and Field Inspection Service, with plants in 16 principal cities, ready to test one part or one million, on a regular basis or to expand your own test capacity in emergencies.

No matter how unique or how routine your inspection problem, call in the Magnaflux nondestructive testing engineer. For thousands of companies, it has been one of the most profitable steps ever taken.



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Quality

IN NONDESTRUCTIVE TEST SYSTEMS

MAGNAFLUX CORPORATION

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Why Do Some Degreasers
Use Less Trichlorethylene?

Unnoticed Changes in a Metal Cleaning Operation Often Affect Solvent Consumption

We were recently asked by a large user of trichlorethylene for a sure procedure for spending the least number of dollars for this chemical.

The procedure necessary to assure the most economical use of trichlorethylene is neither mysterious nor difficult, but it is precise.

To understand it, it is necessary to accept this fact:

- 1) When a change occurs in the product, or
- 2) When a change occurs in manufacturing, or
- 3) When a change occurs in racking, or
- 4) When a change occurs in the human element, or
- 5) When a change occurs in the machine —

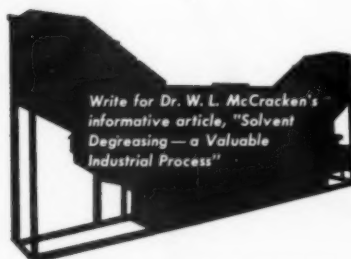
a change will also occur in the quantity of trichlorethylene being consumed. It is not unusual for one of these changes to occur every month, and many times it will go unnoticed. The *only* procedure that will get the *best* result is:

- 1) To ascertain the necessary facts, and
- 2) Have expert appraisal of those facts.

A program can be set up to cover both. We have been doing it for 27 years. We would be very happy to institute such a program for you.

Depend on DETREX for
Every Metal Cleaning
and Processing Need

- PERM-A-CLOR NA (Trichlorethylene)
- Solvent Degreasers
- Ultrasonic Equipment
- Industrial Washers
- Phosphate Coating Compounds
- PAINTBOND Compounds
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- Extrusion and Drawing Compounds
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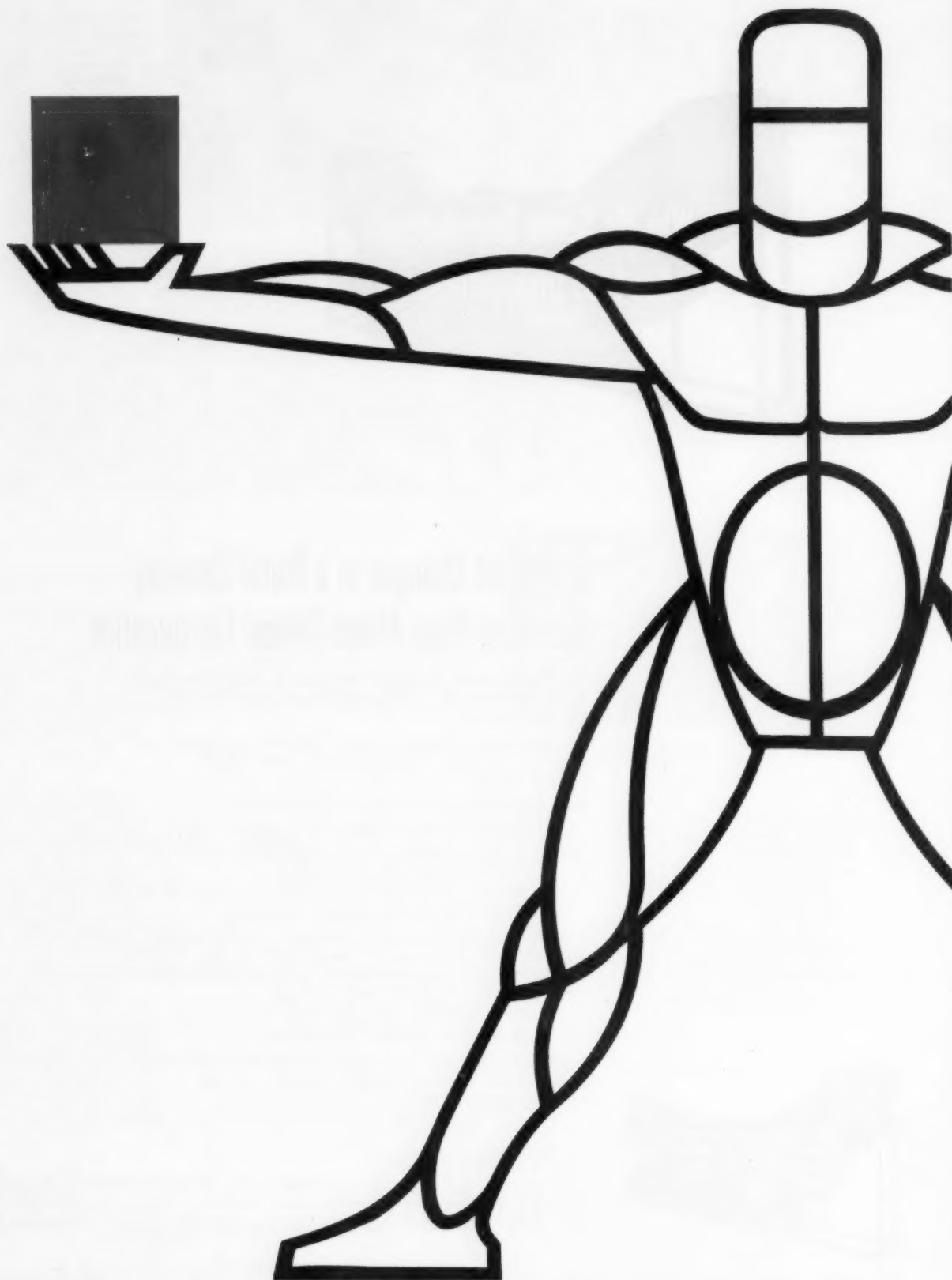
Write for Dr. W. L. McCracken's
informative article, "Solvent
Degreasing — a Valuable
Industrial Process"

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N-A-XTRA is the best low-alloy, extra high-strength steel you can buy. Heat-treated, fully quenched and tempered, it's now available in minimum yield strength levels of 80,000—110,000 psi. This is nearly three times the strength of ordinary carbon steel.

The great strength of N-A-XTRA gives engineers and designers a unique opportunity to eliminate bulky, useless dead weight from finished products. Production men will delight in its superior formability and superb weldability. Send today for our illustrated brochure on N-A-XTRA HIGH-STRENGTH steel. Great Lakes Steel Corporation, Detroit 29, Michigan, Dept. E-8.



GREAT LAKES STEEL

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STEEL

ANALYSIS...in seconds



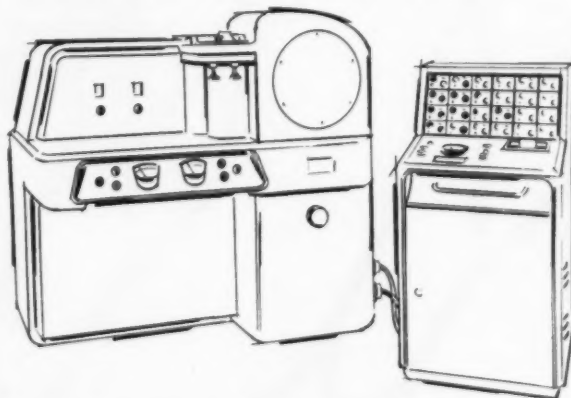
+ plus automatic in-process control

To either meet rigid specifications imposed by quality conscious industrial and governmental needs . . . or to conjunctively eliminate costly rejects of finished parts due to improper alloying, investigate the Norelco Autrometer.

The Autrometer is a multi-indexing automatic spectrograph which utilizes the X-ray spectrum for comparative analysis of any number of repetitive samples (*for as many as 24 different elements without resetting*) against a standard.

Critical quantities of elements essential for correct alloy characteristics can now be determined with incredible speed in *any* stage of production. Incoming raw materials may be quickly analyzed. Heats may be economically held—because the Autrometer permits accurate on-the-spot analysis in a fraction of the time you would expect. Uncannily, the percentage of accuracy can be preset—for each element and no special operator skills are required for operation.

Steel is but one of many industries which makes excellent uses of the Norelco Autrometer. Uses which effect huge economies, eliminate bottlenecks, speed spot-checks and analyses, improve products and increase profits.



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for first quality established in 1910


We have adopted a brand-new trademark, and we hope you like it! • Some of us found it hard to give up our well known tool-in-hand design, which had served faithfully for decades as the insignie of First Quality in tool steel. But times change, and a tool bit no longer represents us. • Our new trademark is for Vanadium-Alloys Steel Company's continually widening range of fine steels—for tools, dies, ultra-high strength structural applications and many other uses. We trust you'll come to know this new mark well, as the sign of "the best obtainable" in the most highly developed steels of our time.



Vanadium-Alloys Steel Company

LATROBE, PENNSYLVANIA

DIVISIONS: Anchor Drawn Steel Co. • Colonial Steel Co. • Metal Forming Corporation • Pittsburgh Tool Steel Wire Co.
SUBSIDIARIES: Vanadium-Alloys Steel Canada Limited • Vanadium-Alloys Steel Societa Italiana Per Azioni • EUROPEAN
ASSOCIATES: Societe Commentryenne Des Aciers Fins Vanadium-Alloys (France) • Nazionale Cogne Societa Italiana (Italy)



now...fatigue testing with infinitely variable stroke and frequency

NEWLY AVAILABLE from Riehle, this Losenhausen hydraulic fatigue testing machine permits complete load and cycle flexibility. Consisting of a console, pulsator and loading unit cylinder, the Losenhausen machine generates strokes up to 10" at low frequencies and modest strokes can be accommodated at frequencies approaching 1000 cpm.

The console measures and indicates the load developed on each cycle, as either fluctuating in tension or compression or as alternating between maximum compression and tension.

LOSENHAUSEN HYDRAULIC FATIGUE TESTING MACHINE WITH PROGRAMMER.

OTHER RIEHLE TESTING MACHINES:

Hydraulic and Screw Power Universal Testing Machines, Construction materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testing Machines, Portable Hardness Testers for Rockwell Readings, Etc.

A programmer that automatically controls frequency, load and stroke can also be supplied. Another valuable Losenhausen advantage, this precise method of setting up tests save time and eliminates step-by-step errors.

FOR ENTIRE ASSEMBLIES

Simply through the use of general purpose testing cylinders, the Losenhausen machine can fatigue test full-scale assemblies and large components. These cylinders apply individual loads at various points.

Standard machines have dynamic capacities ranging from 12,000 to 200,000 pounds. Machines of higher capacity are special. General purpose testing cylinders are available in dynamic capacities from 2,000 to 100,000 pounds.

For more information, circle No. 376

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ADDRESS _____

CITY _____

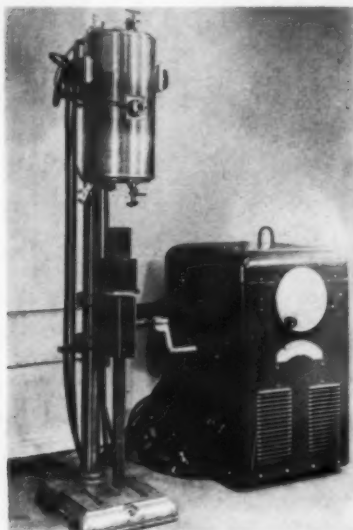
ZONE _____ STATE _____

APPLICATION and EQUIPMENT

new products

Laboratory Furnace

A laboratory resistance furnace that operates to 5000° F. has been announced by the Santa Barbara Div. of Curtiss-Wright Corp. It has an inert gas atmosphere, graphite heating element and carbon insulation.



The heating chamber of the standard unit is 4 in. in diameter by 8 in. high. A hearth lowers out of the heating chamber for easy access to the interior of the unit. Two sighting tubes are placed at top and side of the furnace. The furnace is available with or without automatic temperature controls. For further information circle No. 501 on literature request card, page 48-D.

Thickness Measurement

New smaller-size models of a short-pulse X-ray thickness gage have been announced by the Industrial Gauges Dept. of Daystrom, Inc. Designed for thickness measurements ranging from foil thicknesses of 0.00025 in. to plate thicknesses of 1.5 in., the new short-pulse gage uses a sharply-pulsed, pencil X-ray beam to measure thickness from end to end and side to side, at speeds up to 6000 fpm. The new gage consists of a X-ray generator to supply a controlled pulsed beam,

X-ray incident unit to detect the amount of transmitted energy, and indicator console containing electronic elements to convert and compute the variation of transmitted energy into terms of thickness variations and to initiate corrective action.

For further information circle No. 502 on literature request card, page 48-D.

Thermocouple Accessory

A new thermocouple head assembly with a hinged steel cap that can be flipped open or shut has been announced by Pyrometer Co. of America, Inc. A positive catch on the lock and the moisture and heat-resistant gasket shield the wires against corrosion, abrasion and mechanical damage. The cap is usually of pressed steel, but stainless steel caps are available. A new ceramic block that will take wires from 8 gage down to the smallest sizes, has been designed to fit snugly in the flip-top head.

For further information circle No. 503 on literature request card, page 48-D.

Metal Sorting

A meter which sorts mixed lots of metal parts by its response to their conductivity and permeability has been announced by Metrol, Inc. The instrument will also test both ferrous and



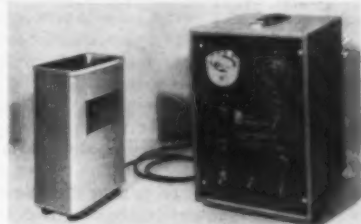
nonferrous metal parts for heat treatment condition, relative hardness and strength, chemical purity, and presence of decarburization. Measurements are made on any flat surface $\frac{1}{8}$ in. in diameter or larger, even when sur-

face is rough, dirty, or covered with layers of paint. Measurements are made in about 3 sec. by touching a hand-held probe to the surface to be tested. The probe radiates an electromagnetic field which excites eddy currents in the test part. Instrument response to conductivity and permeability is displayed on a meter, and by two alarm lights. A variety of plug-in meter scales is available for different metals (see illustration) and conductivity ranges.

For further information circle No. 504 on literature request card, page 48-D.

Ultrasonic Cleaning

National Ultrasonic Corp. has announced a new unit for small part cleaning applications in which high energy density is required. The cleaner



features a 1-gal. heavy-gage polished stainless steel tank with 43% of the bottom covered with driving elements. Actual radiating surface is 12 sq. in. The 115 v., a-c., single-phase, 60-cycle generator, designed for continuous operation, delivers an average power output of 60 watts and produces peaks of 240 watts.

For further information circle No. 505 on literature request card, page 48-D.

Melting Furnace

International Foundry Supply Co. has announced a mobile demonstration unit for on-the-spot demonstrations of the Revecon furnace. The operation of the furnace is demonstrated with the metal used by the foundry being visited. The demonstration consists of melting 100 lb. of aluminum in 12 min. using 0.7 gal. of oil or 100 cu. ft. of 1040 Btu. gas; 200 lb. of brass or bronze in 20 min. using 1.2 gal. oil or 130 cu. ft. of 1040 Btu. gas per 100

*From heat to heat...
bar to bar...order to order...*

TIMKEN® STEEL GIVES YOU UNIFORM FORGING QUALITY THAT SAVES YOU MONEY

You can get money-saving, uniform forged quality in *your* products just as fine as that in the rock bit forgings pictured here. They're made from Timken® steel forging bars. And the photograph of the bits is not retouched.

Savings are yours because Timken steel is uniform from heat to heat, bar to bar, order to order. It never varies in structure, chemistry or dimension. And because Timken steel is so dependably uniform, you don't have to interrupt operations to adjust your equipment.

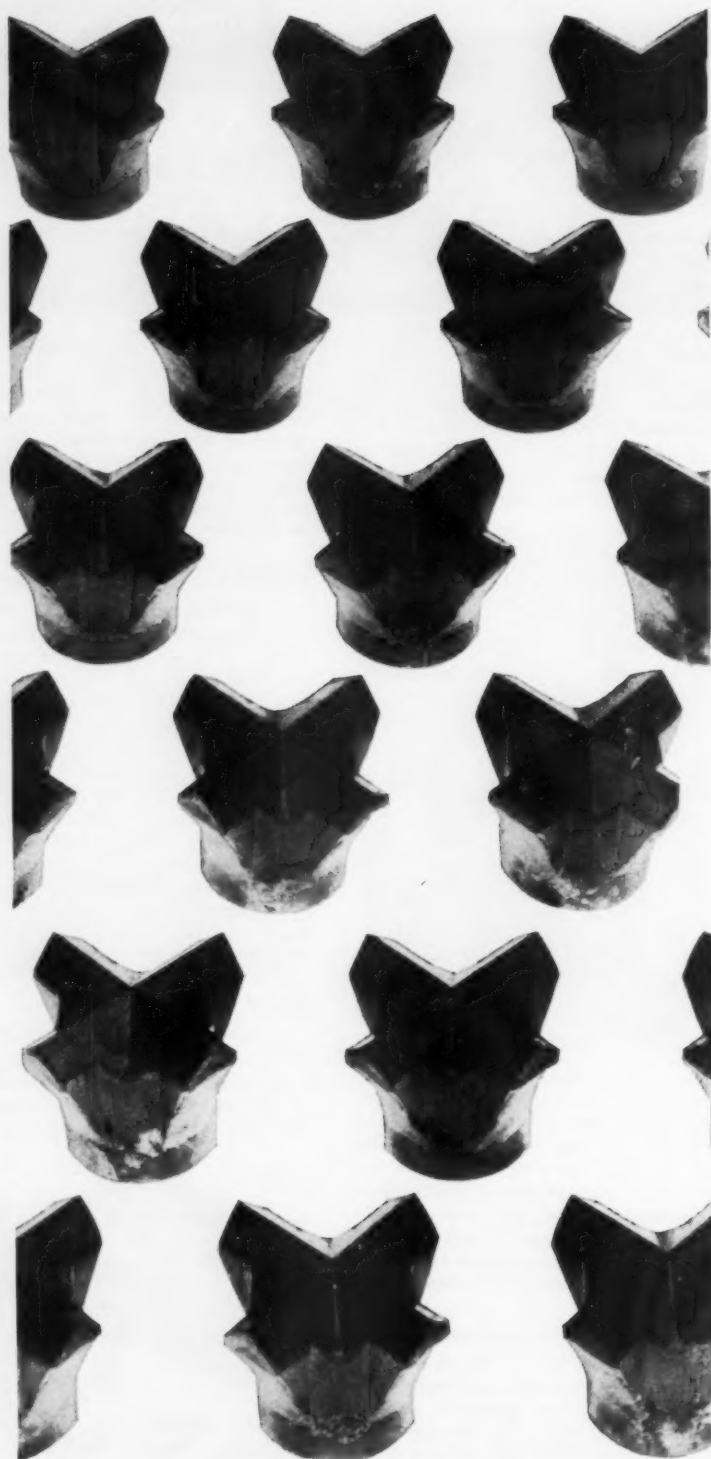
Timken electric furnace fine alloy steel is as uniform a forging steel as you can buy because we take extra quality control steps to make it so. One step—a "first" in the U. S. steel industry—is our magnetic stirrer. This assures equal distribution of the alloys, uniform temperature and working of the slag. Another is our unique method of handling orders individually. It enables us to target our procedures to *your* end-use requirements.

Backing all of our operations is our new Metallurgical Research Center. It comprises one of industry's most modern facilities ranging from an experimental melting laboratory and X-ray spectrometer, to one of the industry's finest technical libraries. All these facilities and the expert metallurgists who use them assure you of the finest possible forging steel with uniformity that means better products, greater savings for you.

To get the most from your modern forging operations, specify Timken steel forging bars. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

WHEN YOU BUY TIMKEN STEEL YOU GET...

1. Quality that's uniform from heat to heat, bar to bar, order to order
2. Service from the experts in specialty steels
3. Over 40 years experience in solving tough steel problems.



TIMKEN® *Fine Alloy* STEEL

lb.; 175 lb. copper in 35 min. using 1.5 gal. oil or 150 cu. ft. of 1040 Btu. gas per 100 lb.; or 100 lb. of iron in 55 min. using 3.4 gal. oil or 360 cu. ft. of 1040 Btu. gas.

For further information circle No. 506 on literature request card, page 48-D.

Plating Solution Filter

Industrial Filter and Pump Mfg. Co. has announced a low-cost, portable plating solution filter which can be moved from one electroplating tank to another. It is mounted on rubber-tired wheels and is designed to pro-

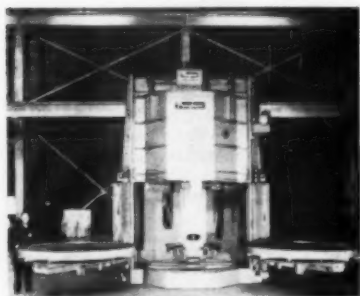


vide 600 gal. per hr. flow capacity and up to 20 sq. ft. of filtration area. It is connected directly to the plating tank. Weighing less than 125 lb. empty and 140 lb. full, the filter requires 3 sq. ft. of floor area.

For further information circle No. 507 on literature request card, page 48-D.

Cleaning Room

A new 8-ft. high twin-table Rotoblast room for cleaning individual castings weighing up to 5 tons has been announced by the Pangborn Corp. With the twin-table system, one work table of the machine is outside where castings or weldments can be



reloaded, turned or unloaded while the other table load is revolving inside the blast cabinet being cleaned. The

blast cleaner features two Rotoblast wheels with 30 hp. motors capable of throwing 100,000 lb. of abrasive per hour. One of the two wheels is mounted on the top deck of the room, blasting 90° to the table top and the second is positioned to provide thorough cleaning of top and sides of the work.

For further information circle No. 508 on literature request card, page 48-D.

Semiautomatic Welding

A semiautomatic process for welding mild steels with up to 75,000 psi. strength has been announced by Arcos Corp. The process uses a flux-cored electrode continuously fed into the weld puddle where it is shielded by CO₂ gas released from the welding gun. The arc is visible at all times permitting the operator to guide it and control the speed of welding. Arcosarc flux-cored wire is made from metal strip specially formed to hold flux powders and deoxidizing agents which form a protective slag over the solidifying molten metal. The equipment, including the welding gun and semiautomatic wire feed equipment, can be connected to most machines of 500-amp. capacity or larger.

For further information circle No. 509 on literature request card, page 48-D.

Plating Fixtures

A line of anode ball baskets used for zinc plating has been announced by Wiretex Manufacturing Co., Inc. Standard models are of steel, 12 to



36 in. in length, 2½ in. in diameter, with a standard 5-in. hook. Basket is designed to hold balls 2 in. in diameter. They are available in steel and other alloys and metals.

For further information circle No. 510 on literature request card, page 48-D.

Heat-Resistant Alloys

Haynes Stellite Co. has announced the availability of several high-temperature alloys in cold rolled thin-gage sheets measuring 0.010 in. thick, 36 in. wide, and 96 in. long. Alloys currently available in this form are Haynes alloy No. 25, Multimet, Hastelloy R-235, Hastelloy X, and René 41.

For further information circle No. 511 on literature request card, page 48-D.

Cleaners

Detrex Chemical Industries has announced a new line of electrolytic cleaners for the removal of intentional

test hardness of CASTINGS FORGINGS BARS the best way with Steel City Brinell Testers

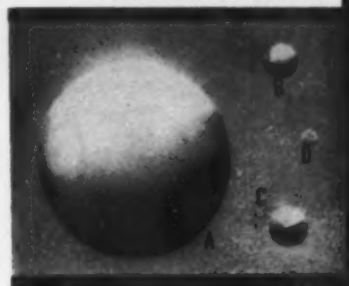


Photo courtesy of A.S.M.

Photograph illustrates the comparative size of impressions made by four different types of hardness tests:

(A) Brinell, (B) Rockwell "B", (C) Rockwell "C", and (D) Scleroscope. Because it covers a larger area, the Brinell impression (A) averages out small inequalities in hardness, surface finish, and complex internal conditions of the metal.

Steel City Brinell Hardness testers are designed to efficiently provide a true picture of the hardness of castings, forgings, bars and other comparatively rough and soft forms of metal. Models are available to facilitate the handling of the work with minimum of effort. True, round Brinell impressions assure dependable testing results. If a Brinell Hardness test is indicated for your material or product — contact Steel City for the right testing machine.

If one of the following types of test is your need—let us help you choose the Steel City machine that meets your individual requirement.

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 Compression	 Transverse	 Hydrostatic
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Write today for FREE literature, describing Steel City testing machines.

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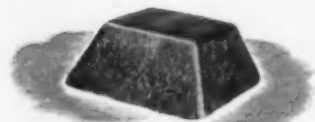
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"Metallic yield goes up with pig-cast ferrosilicon"

Now steel producers can increase silicon recoveries and simplify handling operations with new ELECTROMET pig-cast 75% ferrosilicon. The pigs provide a convenient, uniform lump size for ferrosilicon additions to steel. They produce a higher, more consistent metallic yield because fines are practically eliminated. Ready solubility is achieved because pig additions penetrate the molten steel very quickly. The uniform shape and weight of the pigs (10 to 15 lbs. or 20 to 25 lbs.) make handling easier in both unloading and furnace operations. Your UNION CARBIDE METALS representative will gladly give you further information.

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Pigs are easy to handle and give a high metallic yield.



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soils from aluminum and aluminum alloys, zinc, steel, brass, copper, nickel, and other metals. The high alkalinity of the new cleaners gives high saponification when not preceded by other cleaning methods. They are recommended for use in batch-type plating shop applications.

For further information circle No. 512 on literature request card, page 48-D.

Batch-Type Furnace

A batch-type, controlled-atmosphere furnace for bright metal finishing in heat treatment has been announced by Surface Combustion Corp. Increased furnace production is obtained by incorporating a specially designed side



cool chamber adjacent to the furnace vestibule. This permits work to move between the heating chamber, furnace vestibule and annealing chamber without leaving the furnace proper. The cooling chamber can cool an 800-lb. load from 1550 to 600° F. in 5 min. For further information circle No. 513 on literature request card, page 48-D.

Electrocleaner

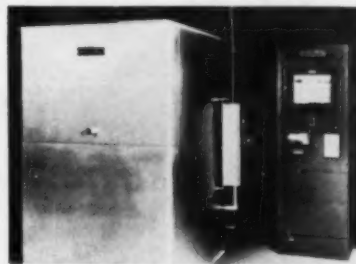
A new heavy-duty, high-conductivity, anodic cleaner for steel has been announced by Enthone, Inc. The new product is designed for anodic cleaning at high current density. Enbond Cleaner FE-84 is furnished as a powder that may be dissolved in water at concentrations of 8 to 12 oz. per gal. and used at 180 to 200° F. For further information circle No. 514 on literature request card, page 48-D.

Strippers

Heatbath Corp. has announced two new dry powdered products for stripping anodized and oxide coatings from aluminum. Striplal No. 5 is an alkaline powder that can be used in a steel container at 2 lb. per gal. of water without heat for rapid stripping of anodized or oxide coatings. Striplal No. 4 is an acid powder used at 1 lb. per gal. of water at a temperature of 180 to 190° F. for removing anodic coatings leaving the aluminum bright and free from smut. Both products contain inhibitors for preventing attack on the underlying aluminum. For further information circle No. 515 on literature request card, page 48-D.

Heat Treating

A new controlled-atmosphere electric furnace has been announced by Waltz Furnace Co. Doors are air-

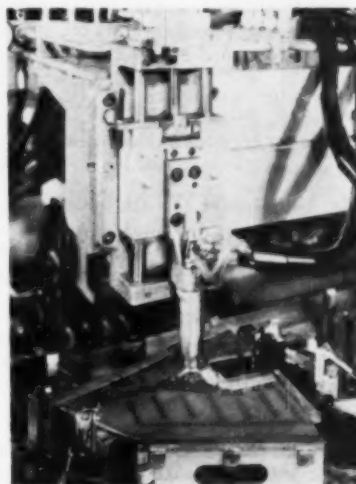


operated by means of a foot valve. Ribbon of 80% Cr—20% Ni of extra large cross section forms the elements which are looped and slid into grooves in the refractory lining. The elements operate on 110 v. from 220 or 440 v. step-down transformers located in the base of the furnace.

For further information circle No. 516 on literature request card, page 48-D.

Welding Equipment

The Linde Co. has announced a new pilot-arc for positive-arc starting for inert-gas tungsten-arc spot welding or cutting especially in mechanized



installations where torches must be fired according to a predetermined schedule. Pilot-arc starting eliminates all high-frequency interference problems and avoids the contamination problems of retract starting. The pilot-arc keeps a ball of incandescent gas within the cup so that the arc is always ready to fire as soon as potential is applied between torch and workpiece. The current is adjusted to about 5 amp. and is maintained between electrode and water-cooled nozzle. A small quantity of shielding gas flows

WORD FROM

Waukee...

FLO-METERS FOR ALL INDUSTRIAL GASES

If you use industrial gases in heat treating or processing, then you should have the Waukee Flo-Meter Catalog — Bulletin 204 in your files. For the accurate flow measurement of air and industrial gases, Waukee provides meters from 3 C.F.H. to 25000 C.F.H.

ACCURACY!

Waukee Flo-Meters stay accurate in your shop because they are easy to clean. You can see through a Waukee Flo-Meter when you clean it and it takes less than two minutes. The meter can be completely disassembled without the use of tools.

BUILT-IN FLOW CONTROL VALVES

All sizes of Flo-Meters can be supplied with built-in valves for precision control purposes. The valve is located in the

top of the meter. This feature makes installation extremely simple as there is no need to drill special holes for control valve when panel mounting.



AVAILABLE FOR ALL GASES

Air	Endothermic
Ammonia	Exothermic
Argon	Forming Gas
Butane	Helium
Carbon-Dioxide	Hydrogen
Carrier Gas	Natural Gas
City Gas	Nitrogen
Dissociated Ammonia	Oxygen
	Propane

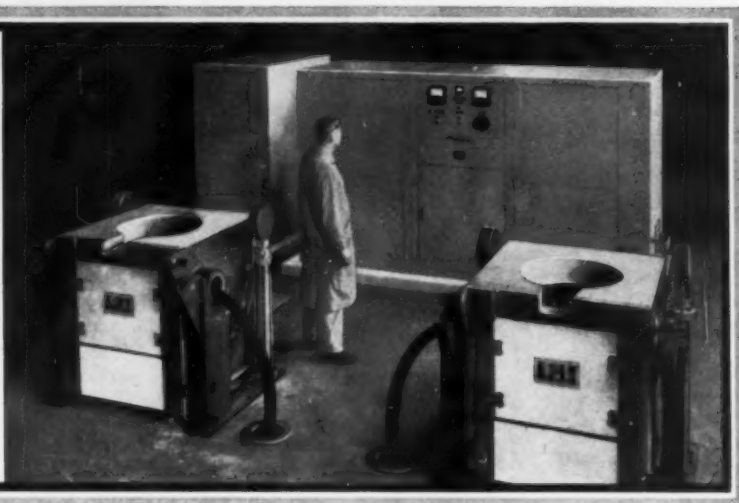
Complete capacity tables are shown in Bulletin 204 and we will be glad to send it along with prices. Write Waukee Engineering Co., Inc., 5140 North 35th Street, Milwaukee 9, Wisconsin. R.C.O.

Waukee

FLO-METERS
GAS-AIR MIXERS
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NOW INDUCTION MELTING COSTS LESS THAN EVER...

through
new
Multiductor*
power



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- * **LESS INITIAL COST**—The initial cost of a typical Multiductor is less than conventional motor generator type equipment. Further, because the unit is shipped completely assembled and wired, installation costs are drastically reduced. Multiductor requires minimum floor space and uses standard 3-phase, 60-cycle power from ordinary sources.
- * **LESS OPERATING COST**—Operation is so nearly automatic that inexperienced hands quickly become expert operators. Output can be varied continuously . . . while under load . . . from zero to maximum with easy-to-use controls. Damage by overload is practically impossible.
- * **LESS MAINTENANCE**—Multiductor is essentially a static frequency converter. It contains no rotating parts, nothing to wear out, and little to maintain. The number of heats per refractory lining has maintained an unusually high average, going as high as 400 heats with some alloys.
- * **LESS MATERIAL COST**—The strong electromagnetic stirring action of Multiductor powered furnaces promotes rapid melting and diffusion of alloying elements with extremely low metal loss . . . is ideally suited for melting low cost scrap such as borings, turnings, and chips.
- * **SEE A DEMONSTRATION**—Discover for yourself why more and more foundries—at least an additional one each week—are finding that Multiductor Powered Induction Furnaces are one of the greatest melting economizers in history . . . on small furnaces as well as 10-ton units. Write Ajax Electrothermic for a demonstration or an engineer's visit without obligation. Data bulletins are also available.

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P.O. Box 1418 • Lator & Hancock Streets
Trenton 7, New Jersey

continuously and protects the electrode while the pilot is on. When the torch is brought into welding position against the work, and the trigger pulled, the pilot-arc provides a path for the main welding current which instantaneously flashes across to the work and makes the spot weld.

For further information circle No. 517 on literature request card, page 48-D.

Stainless Steel Plates

G. O. Carlson, Inc., has announced plates of Type 304 stainless steel which measure 461 by 179 by 2 in. and 451 by 184 by 2 in. and weigh over 49,000 lb. each. They were pro-



duced to ASTM A240, Grade S for use in an atomic energy application. The melt was prepared in a 70-ton capacity furnace and poured into extra large ingot molds. Then these ingots were slabbed and rolled into plates. The plates were flame and abrasive-cut into two huge semi-circles.

For further information circle No. 518 on literature request card, page 48-D.

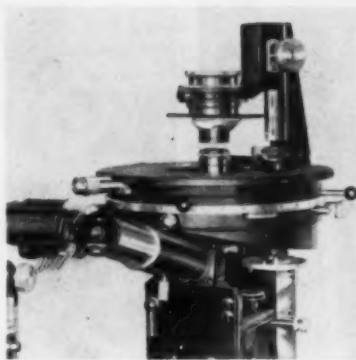
Cement

A new thermosetting carbonaceous cement has been announced by the Electrode Div., Great Lakes Carbon Corp. The one-package premixed cement is available in a range of consistencies and is ready for immediate application without stirring. The cement is specially designed for high-strength bonding of carbon-brick blast-furnace linings and graphite blocks in chemical equipment.

For further information circle No. 519 on literature request card, page 48-D.

Specimen Holder

A magnetic specimen holder that can be used with any inverted metallurgical microscope has been announced by William J. Hacker & Co. This holder permits survey of small specimens without embedding them. Using plasticine or a similar product and a specimen press, the sample is attached to a metal object slide that is then placed under the magnet of the specimen holder. The tension between slide and magnet can be regulated and the slide with the specimen can be shifted into any desired posi-

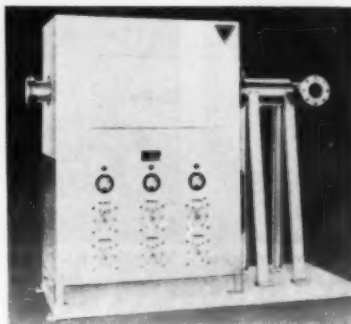


tion for survey of the entire sample without marring its surface.

For further information circle No. 520 on literature request card, page 48-D.

Tube Furnace

The Pereny Equipment Co. has announced a new gas-tight electric tube furnace for work requiring temperatures up to 2800° F. It has a 5-in. I.D. impervious mullite tube, with silicon-carbide heating elements spaced equidistant around it, and providing a 30-in. long hot zone with three separate zone controls for temperature



control. Separate transformers, on each of three phases, are of the voltage regulating type with 36 fine-to-coarse taps. The over-all length of the unit is 60 in.

For further information circle No. 521 on literature request card, page 48-D.

Rolling Mill

A two-high/four-high combination rolling mill for nuclear metals production and research work has been announced by Loma Machine Manufacturing Co., Inc. The new machine is completely enclosed to allow the processing of reactive metals. To facilitate remote control operation, the mill is equipped with a semi-automatic roll changing device comprising a sliding way, a quick-disconnect screwdown, a universal spindle support and pull-off oil lubrication lines. The entire roll assembly may

36

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abrasives

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With new, precision controlled equipment and specialized techniques "Malleabrasive" is now job-made to meet each individual cleaning condition.

Why settle for make-shift, general purpose abrasives when you can have "Malleabrasive" tailor-made for you? We'll welcome the chance to tell you how you can benefit.

Write us.



THE GLOBE STEEL ABRASIVE CO.
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Sold by many leading distributors of heavy supplies from coast to coast.

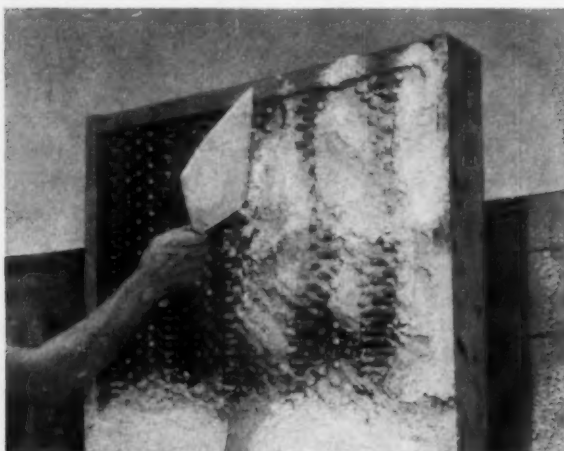
MALLEABRASIVE



Casting furnace linings in place can be speedily accomplished with any B&W Refractory Castable. Here, tough, erosion-resistant B&W Kaocrete-D is cast in a lining that will be ready for service soon after installation.



Gunning B&W Kromight-Gun assures complete penetration of irregular areas. This 3200 F refractory material is excellent for studded open hearth doors and similar metalworking installations.



Slap trowelling can be the most effective way of forming a vertical or overhanging section of lining, provided the castable has an exceptionally adhesive, plastic texture. B&W Kaocrete-B, possessing these properties, is widely used in this type of installation.



Vibrating B&W Kaocrete-32 in place to form electrode rings in an electric furnace. This method of installation provides density and strength, and eliminates laminations, air bubbles and pockets, thus permitting economical, long life.

How B&W refractory castables solve application problems

Installing refractory linings quickly and inexpensively is a major concern of furnace builders and operators. Each of the many different types of metal working furnaces presents its own particular installation problems. To meet these widely differing conditions, B&W offers not just one, but a range of *specialized* refractory castables. Each is *engineered* to provide savings in installation time. *Specialized* B&W Refractory Castables save money by eliminating the

need for costly inventories of special shapes. The use of castables speeds up new construction and repair jobs and permits simplified, improved furnace design together with long life—in short, superior performance over a wide range of furnace operating conditions.

B&W Bulletin R-35A gives additional information on versatile B&W refractory castables. Write for copy to The Babcock & Wilcox Company, 161 East 42nd Street, New York 17, N. Y.

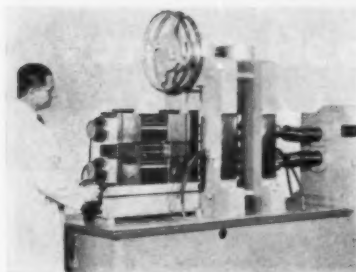


B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

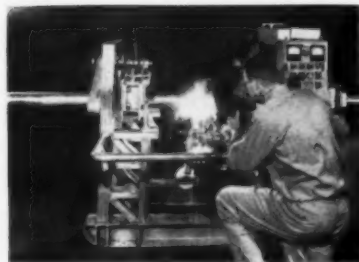


be moved into or out of the mill, and roll changes can be made.

For further information circle No. 522 on literature request card, page 48-D.

Pipe Welding

A new automatic pipe welding machine capable of producing welds with full penetration without the use of back-up rings has been announced by Aluminum Co. of America. The unit completes a pass on 4-in. pipe in 11 sec. It can process all tubular products with outside diameters of 4 to 11 in. Vapor-proof cabinets contain all elec-



trical controls. Head of a new automatic machine can be positioned through a range of welding angles, and can be set to oscillate, automatically moving back and forth across weld width to insure complete filling. For further information circle No. 523 on literature request card, page 48-D.

Temperature Chamber

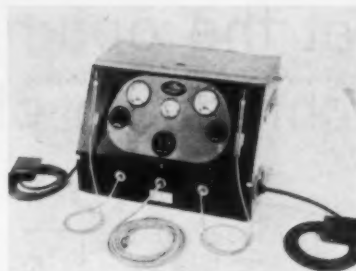
Missimers, Inc., has announced a new chamber for production processing and testing at temperatures from -100 to $+350^{\circ}$ F. This bench-type unit has a 1-cu. ft. working space. It employs the cascade mechanical refrigeration system for low temperatures and nichrome wire elements for heating. One 115 v. outlet furnishes sufficient power.

For further information circle No. 524 on literature request card, page 48-D.

Metal Cutting

A new, dual version of their industrial airbrasive unit has been announced by S.S. White Industrial Div. This tool cuts or abrades almost any

hard or brittle material. The Duplex Model D combines two units in one housing, making possible added capacity or a choice of abrasive materials. The airbrasive unit cuts or abrades with a controlled stream of gas-propelled abrasive, emerging from the cutting tip nozzle at 1100 ft. per sec. The abrasive material ordinarily employed is aluminum oxide in the 27

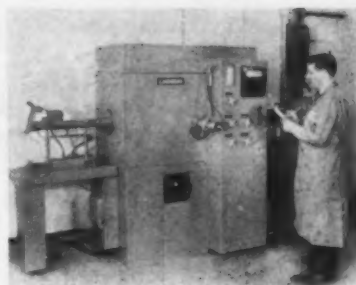


micron range. Any compressed gas source of 80 psi. can be used, as long as the gas is dry.

For further information circle No. 525 on literature request card, page 48-D.

Graphite Tube Furnace

A new high-temperature graphite tube furnace has been announced by



the Pilot Plant Equipment Div. of Lindberg Engineering Co. It may be used for sintering of powder metals. The over-all operating temperature range is 1600 to 5000° F.

For further information circle No. 526 on literature request card, page 48-D.

Welding Positioners

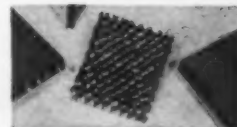
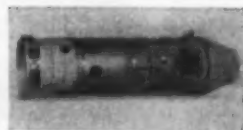
A new device regulating travel speed of parts of various diameters to be welded has been announced by Harnischfeger Corp. One dial sets for inches per minute, another for weld diameter to the nearest 0.01 in. Both can be varied while the weldment is in motion. In addition to full control of rotation and tilt, both forward and reverse, there is a switch which permits maximum table revolutions per



We Furnace Braze Stainless Alloys

To eliminate problems of distortion, stress, oxidation, and porous welds

The advantages of stainless alloy brazing in dry hydrogen or vacuum environment furnaces are many. And the use of brazing for high-temperature service parts is growing just as fast as potential users learn to design for it. We offer technical design assistance to further the acceptance of this modern joining technique. Ten years of pioneering this field, plus operating three stainless processing plants, plus manufacturing our own Microbraz® brazing alloys, fully qualifies us to give initial guidance to your design crew in planning brazed stainless components. Call TWinbrook 3-3800 in Detroit, or write to find out how we might help you.



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News about COATINGS FOR METALS

from Metal & Thermit Corporation

How to get the optimum protection of bright chromium plating

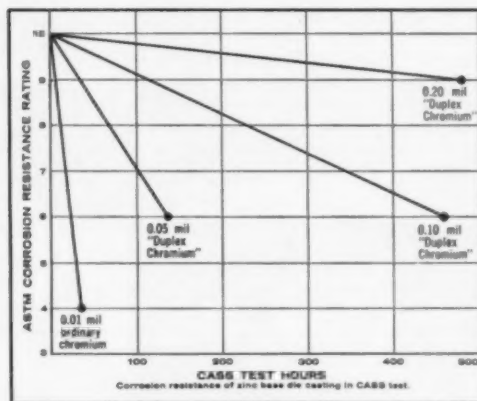
There are three requisites to increasing corrosion protection from chromium plating. (1) The deposit must be sufficiently thick. (2) There should be a crack-free chromium base topped by a special, finely cracked chromium deposit. (3) The plate should be more uniformly distributed over the part, so that recessed areas, too, are assured at least 0.03 mils minimum chromium thickness.

All of these requirements are easily met through UNICHROME SRHS® CHROMIUM plating processes. Work done for the automotive industry, long plagued by corrosion of brightwork in outdoors exposure, provides a good case in point.

AN ANSWER TO OUTDOOR CORROSION

Note the results in the chart at right. In all cases, the thickness of undercoats was kept constant. Only the chromium plate was varied... from ordinary to "Duplex", and progressively thicker. M&T "Duplex Chromium" calls for first using Unichrome Crack-Free Chromium and its ability to throw into recesses and give a more uniform and fracture-free plate. This is followed by another deposit of Unichrome SRHS Chromium, with its *controlled* cracking. With increas-

Despite severe service conditions, automotive brightwork can stay bright now, due to the additional corrosion protection that M&T "Duplex Chromium" provides.



Zinc die cast specimens, all plated with 0.75 mil copper and 0.75 mil nickel prior to chromium lasted as shown above in the severe CASS test (Copper accelerated acetic acid salt spray). Ordinary chromium fared poorly. Optimum protection was approached by using Crack-Free Chromium and increasing the deposit thickness.

ing thickness, the protection increased tremendously. Durability as determined by rigorous, accelerated corrosion testing techniques was multiplied as much as 20 times.

WIDELY USEFUL FINISH

While the above case concerns itself specifically with an automotive problem, it indicates what thicker chromium in general, and crack-free chromium in particular can do for other design problems involving corrosion and wear. This plate blocks infiltration of corrosives to underlying metal.

Technical Papers giving full details on the advantages of thicker chromium deposits are available for the asking. Write METAL & THERMIT CORPORATION, Rahway, New Jersey.

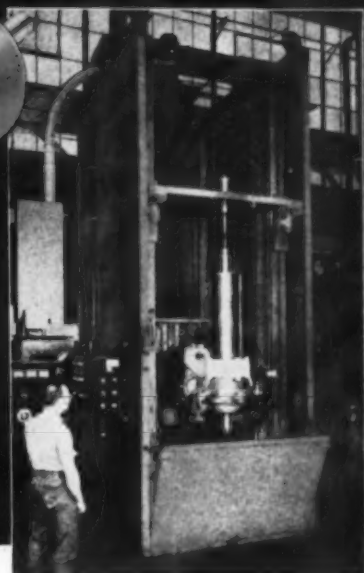
**METAL & THERMIT
CORPORATION**

Former Heat-Treating Time—28¼ HOURS
TOCCO Heat-Treating Time—30 MINUTES

Plus
\$108 saved on
every mill roll



This special mill roll hardening fixture is powered by two 200 KW, 3000 cycle TOCCO machines. Mill roll shown is 12" diameter by approx. 60' long.



with TOCCO* Induction Heating

When progressive engineers at The McKay Machine Company switched from conventional heat-treating methods to TOCCO induction hardening of their mill rolls, they achieved not only increased production but also important cost savings, and perhaps most important of all, a greatly improved product.

56 Times as Fast!

Formerly mill rolls required a 12-hour heat, a 15-minute salt brine quench, 12 hours tempering and a 4-hour cooling period. With TOCCO the whole job is done—and done better—in just 30 minutes—56 times as fast!

Here's Real Economy

Reduced furnace time saves \$28.00 per roll. More important, grinding time is cut in half (saving \$80 per roll) because TOCCO minimizes distortion and there's less stock that must be removed. Runoff used to be as much as ¼"—frequently requiring a separate straightening operation.

Product Improved

Because TOCCO "scans" the mill roll, i.e. heat treats it progressively, only a small section is at critical temperature at any one time. That's why distortion is minimized and little finish grinding is required. This means that TOCCO-hardened mill rolls have a *more uniform case-hardened depth* than possible with old fashioned methods which in turn means longer life and better performance.

• • •

Why not have a TOCCO engineer survey your plant to determine where TOCCO can reduce your costs, increase production speed and improve product quality?

THE OHIO CRANKSHAFT COMPANY



TOCCO

*Trade Mark Reg.
U. S. Pat. Off.

Mail Coupon Today

**NEW FREE
BULLETIN**

THE OHIO CRANKSHAFT CO.
Dept. R-9, Cleveland 5, Ohio

Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating."

Name _____

Position _____

Company _____

Address _____

City _____ Zone _____ State _____



High voltage "lightning" discharge at a Malleable test block.

Toughness is Malleable

Under the slamming, bruising strain of a bulldozer's roughshod ride... inside the battering air hammer... against the repetitive concussion of a machine gun's smashing action... wherever conditions are really brutal, Malleable iron castings prove their ruggedness.

When you're looking for toughness, it will pay you to investigate Malleable castings. Contact one of the progressive firms that displays this symbol—

If you wish, you may inquire direct to the Malleable Castings Council,
Union Commerce Building, Cleveland 14, Ohio, for information.



New Malleable Irons Meet Gruelling Service Tests

Toughness is a vital requirement in stressed parts. Each application, however, requires a particular combination of physical characteristics to be sufficiently "tough."

Whatever the specific requirements, one of the finest groups of materials available is the Malleable irons, as illustrated in the tables below.

Tensile Properties—A.S.T.M. Minimum Specifications Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.	Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
Standard				53004	80,000	53,000	4
35018	53,000	35,000	18	60003	80,000	60,000	3
32510	50,000	32,500	10	80002	100,000	80,000	2
Pearlitic				Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.			
45010	65,000	45,000	10				
45007	68,000	45,000	7				
48004	70,000	48,000	4				
50007	75,000	50,000	7				

Other Mechanical Properties Standard and Pearlitic Malleable Irons

Modulus of Elasticity in Tension, p.s.i.

Ratio of Fatigue Strength to Tensile Strength

Shear Strength—% of Tensile Strength

Torsional Strength

Compressive Strength, p.s.i.

Standard	Pearlitic
25,000,000	26,000,000—28,000,000
0.54	0.40—0.50
80—90%	70—85%
Approximately equal to Tensile Strength	
200,000	250,000



Malleable's toughness is illustrated in a severe test conducted by a manufacturer of cab-over-engine trucks. To be absolutely sure of the strength and toughness of a variety of components in the cab, including the critical Malleable iron cab support hinges, a truck was crashed at high speed into a barricade of ice. Result—no hinge damage, even though the truck was seriously battered.

Service-Demonstrated Toughness

Highway railing posts demonstrate Malleable castings' use where impact resistance is critical. As an example, thousands of Malleable railing posts line the Connecticut State Thruway. The State Highway Department reports that there have been no failures of the Malleable iron posts although other materials have failed in several cases.

It is also because of Malleable's toughness that so many of the highest quality hand tools are made of Malleable iron. One leading tool manufacturer tests the quality of its pipe wrenches by using a trick well known as the best way to break a wrench. The wrench

jaws are put on a rigid bar, a long pipe is slipped on the handle, and the tester heaves his weight downward on the pipe. Because of their confidence in Malleable's toughness, this company unconditionally guarantees every Malleable wrench housing against distortion and breakage. Another hardware manufacturer makes a similar guarantee against breakage on its line of Malleable vises.

But Malleable iron's proven performance in field service is only one reason for its wide use. To this, you must add Malleable's low first cost, design flexibility, and excellent machinability. This combination offers unique advantages over other metals.

Design and Production Assistance Available

To assist in the use of Malleable castings, a special bulletin on toughness—Data Unit No. 105—is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, O.

These bulletins and engineering and planning assistance are also readily available to you from any member of the Malleable Castings Council.

These companies are members of the



CONNECTICUT

Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE

Eastern Malleable Iron Co., Wilmington 99

ILLINOIS

Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA

Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS

Belcher Malleable Iron Co., Easton

MICHIGAN

Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA

Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE

Laconia Malleable Iron Co., Laconia

NEW JERSEY

Meeker Foundry Company, Newark 4

NEW YORK

Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division
Eastern Malleable Iron Co., Solway
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO

American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA

Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS

Texas Foundries, Inc., Lufkin

WEST VIRGINIA

West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN

Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46



KNOW YOUR ALLOY STEELS...

This is the third of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What Does Grain Size Mean In An Alloy Steel?

The grain size of alloy steels is generally understood to mean austenite or inherent grain size, as indicated by the McQuaid-Ehn carburizing test. Austenite grain size should be distinguished from ferrite grain size, which is the size of the grains in the as-rolled or as-forged condition with the exception of those steels that are austenitic at room temperature. When steel is heated through the critical range (approximately 1350 to 1600 deg F for most steels, depending on the composition), transformation to austenite takes place. The austenite grains are extremely small when first formed, but grow in size as the temperature above the critical range is increased, and, to a limited extent, as the time is increased. It is apparent, therefore, that both time and temperature must be constant in order to obtain reproducible results.

When temperatures are raised materially above the critical range, different steels show wide variations in grain size, depending on the chemical composition and the deoxidation practice used in making the heat. Heats are customarily deoxidized with aluminum, ferrosilicon, or a combination of deoxidizing elements. Steels using aluminum or other deoxidizers in carefully controlled amounts maintain a slow rate of grain growth at 1700 deg F, while heats finished with other deoxidizers, usually ferrosilicon, develop relatively large austenite grain size at temperatures somewhat below 1700 deg F.

The McQuaid-Ehn test is the one ordinarily used for determining grain

size. Steel is rated with a set of eight ASTM charts that are compared one at a time with a specially prepared steel sample until one is found to match. Number 1 grain size, the coarsest, shows $1\frac{1}{2}$ grains per sq in. of steel area examined at 100 diameters magnification. The finest chart is Number 8, which shows 96 or more grains per sq in. at the same magnification.

Properties Affected by

Grain Size

Fine-grain steels (grain sizes 5, 6, 7, and 8) do not harden as deeply as coarse-grain steels, and they have less tendency to crack during heat-treatment. Fine-grain steels exhibit greater toughness and shock-resistance—properties that make them suitable for applications involving moving loads and high impact. Practically all alloy steels are produced with fine-grain structures.

Coarse-grain steels exhibit definite machining superiority. For this reason a few parts which are intricately machined are made to coarse-grain practice.

The correct specification and determination of grain structure in steel is a subject that has been given long study by Bethlehem metallurgists. If you would like suggestions on this or any other problem concerning alloy steels, these men will be glad to give you all possible help.

In addition to the entire range of AISI alloy steels, Bethlehem produces special-analysis steels and the full range of carbon grades.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL





minute without disturbing the other weld settings.

For further information circle No. 527 on literature request card, page 48-D.

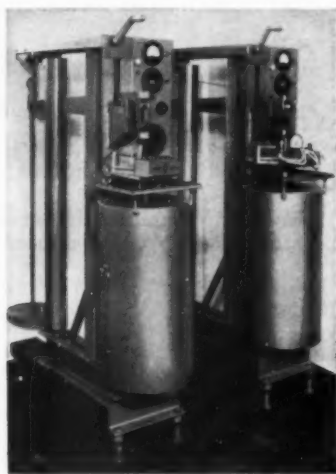
Temperature Control

The maximum size of the d.c. saturable reactors manufactured by Sorgel Electric Co., and described in the June issue of Metal Progress should have been 3000 kva. instead of 300 kva. These reactors are used for controlling and regulating the temperature of electric furnaces. Units consist of a laminated steel core and a series of coils similar to a transformer in which the core is magnetized and saturated to a varying degree by d.c. current.

For further information circle No. 528 on literature request card, page 48-D.

Creep Testing Machines

A new line of stress-rupture-creep testing machines has been announced by the Tinius Olsen Testing Machine Co. Two models are currently available—140 to 6000 lb. or 280 to 12,000 lb. Testing temperatures to 2462° F.



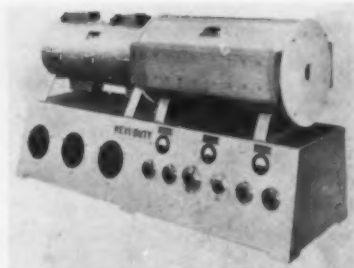
are maintained within $\pm 2^\circ$ F. by an integral thermostat in three individually regulated and controlled heating zones. Specimen extension or creep is

indicated on a large dial indicator with 0.001-in. graduations.

For further information circle No. 529 on literature request card, page 48-D.

Furnaces

Hevi-Duty Electric Co. has announced several standard precision furnaces for the transistor and semiconductor industries. They are available in three maximum temperature ranges of 1850, 2200, and 2600° F. Temperature uniformity is assured through multiple-zone heating. Saturable reactor controls provide precise temperature selection. Controlled pre-

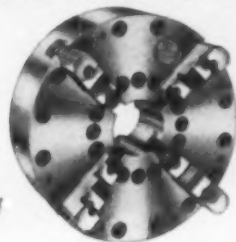


heat and cooling zones can also be supplied with the furnaces.

For further information circle No. 530 on literature request card, page 48-D.

dependable...

Whiton
**HARDENED PLATE
CHUCKS for**
High Precision Work



In high-precision, low-cost turning operations the **right** chuck for the lathe and the job is of utmost importance. Whiton's Independent 4-jaw chuck — with more than 100 years experience behind it — features jaw slots formed by separate plates hardened and finish ground **before** mounting on the chuck body.

The Right Chuck

FOR THE JOB!

The **Right** Chuck for the job is a Whiton! Whiton hardened plate type chucks available from 8" to 18" diameter for American Standard Spindle Noses: Types A, D, & L. Furnished with style No. 6 American Standard Tongue and groove or solid type reversible jaws.

Complete technical information available on request.



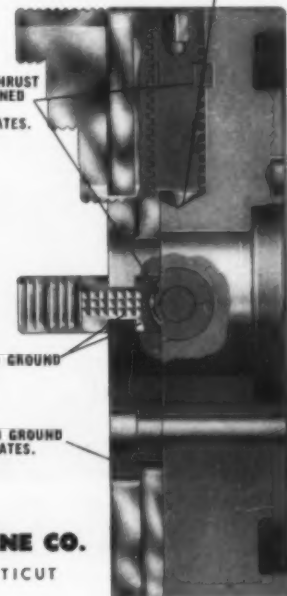
THE WHITON MACHINE CO.
NEW LONDON, CONNECTICUT

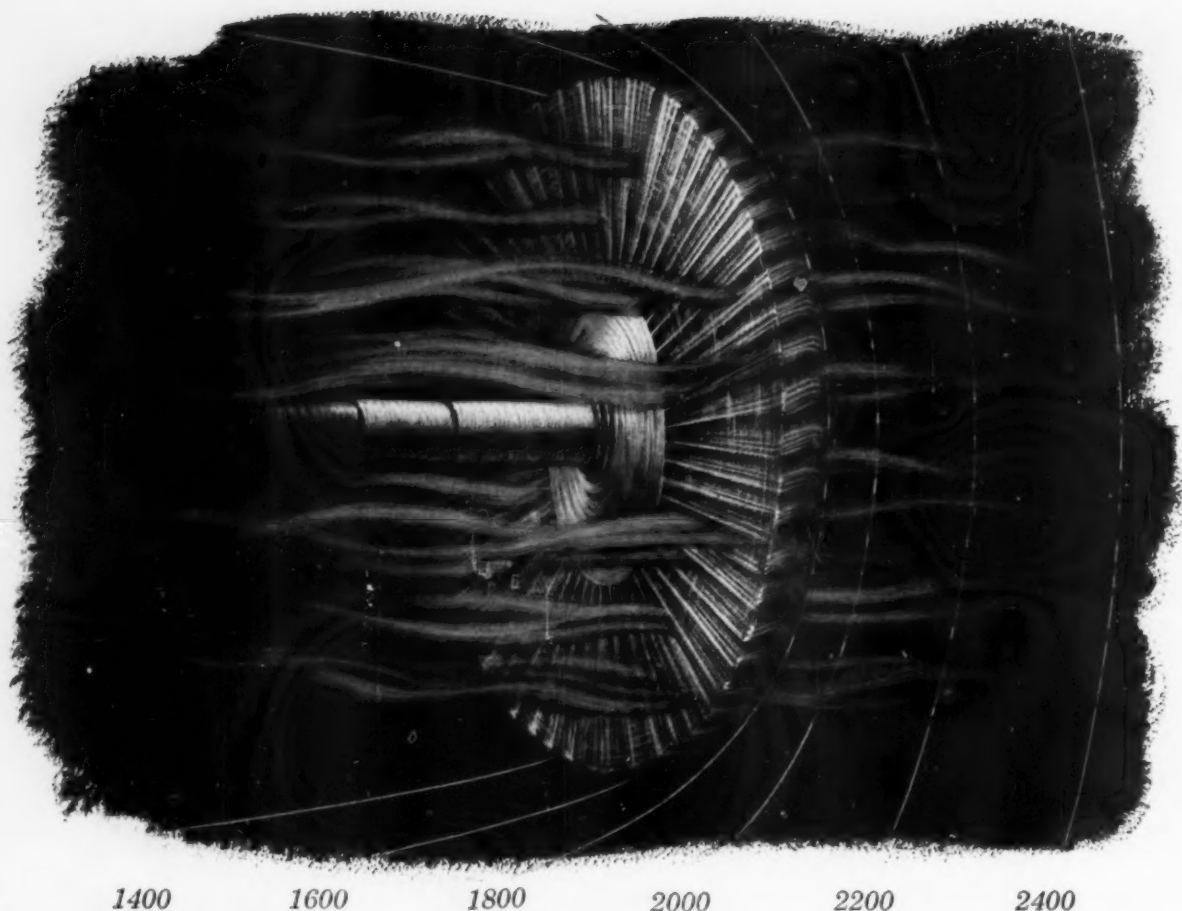
SCREW CHAMBER NOT BORED
THROUGH TO CENTER HOLE —
INCREASING STRENGTH OF CHUCK BODY.

FULL CIRCLE THRUST
BEARING RETAINED
IN BODY BY
SEGMENTAL PLATES.

HARDENED AND GROUND
JAW SLOTS.

HARDENED AND GROUND
SEGMENTAL PLATES.





Boring into the Heat Barrier



Heat-treating facilities are part of the complete metallurgical services available at Haynes Stellite Company.

Extremely high centrifugal forces, plus prolonged operation well above 1700 deg. F.! That's the achievement of thousands of jet engine turbine wheels and blades investment-cast of HAYNES high-temperature alloys.

Resistance to stress, to thermal shock, to erosion, corrosion, and to fatigue are typical properties that make these alloys so extremely useful in many of the hot spots in today's jet engines, ramjets, missiles, and rockets.

Whether investment- or sand-cast, wrought, vacuum melted, or air melted, there's a HAYNES high-temperature alloy to meet your needs.

HAYNES

ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation
Kokomo, Indiana

Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.



"Haynes" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.



RE-ENTRY SHIELDS



WYMAN-GORDON IS FORGING RE-ENTRY SHIELDS

- Copper in production
- Beryllium in limited production
- Reinforced plastics in development

WYMAN-GORDON

FORGING

ALUMINUM MAGNESIUM STEEL TITANIUM BERYLLIUM MOLYBDENUM COLUMBIUM
AND OTHER UNCOMMON MATERIALS

WORCESTER, MASSACHUSETTS

HARVEY, ILLINOIS
DETROIT, MICHIGAN

GRAFTON, MASSACHUSETTS
FORT WORTH, TEXAS

FRANKLIN PARK, ILLINOIS
LOS ANGELES, CALIFORNIA

SEE THE ANSWER TO

YOUR HEAT TREAT PROBLEM AT THE HAYES LAB



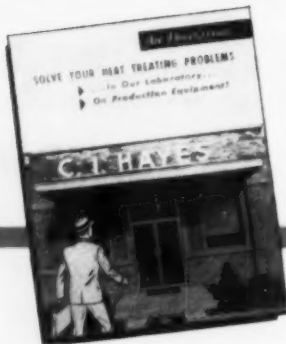
Ever since 1918, C. I. Hayes has maintained a laboratory of the latest *production-line* furnaces and allied equipment (not lab models) on which actual heat treating processes can be duplicated and evaluated. Here you can take an active part in developing the heat treat procedure that will give you the exact results you need. You participate, too, in developing equipment that's coordinated to your own particular work.

CUSTOMERS ARE WELCOME to make use of the lab without cost or obligation. Hayes equipment *plus* our engineering know-how *plus* the Hayes library of case histories—this combination is ready to help you solve your problems . . . either with standard furnaces, or special designs for special work.

HAYES SHOWED THE WAY—others followed. There are several "Chinese copies" of the Hayes lab in industry today . . . proof positive that the right way to solve heat treat problems is the Hayes way—by experimentation and demonstration—not by "sweet talk".



BULLETIN 1961 gives full lab details . . . write for your copy today.



WANT RESULTS GUARANTEED? Take advantage of our lab—and its range of furnaces and atmosphere generators—whether you're hardening low carbon steel, sintering refractory metals, or brazing stainless. Let us show you how to improve your product, reduce costs, and speed production.

C. I. HAYES, INC.

Established 1905

802 WELLINGTON AVE., CRANSTON 10, R. I.

ELECTRIC  FURNACES

APPLICATION and EQUIPMENT

new literature

532. Abrasive Cleaning

Folder on Malleabrasive for airless blast cleaning equipment gives advantages, grades, equipment it can be used with and parts that can be cleaned. *Globe Steel Abrasive*

533. Abrasive Cleaning

Catalog 57-WX on brush types, sizes, speeds, filaments. Aids to power brush selection. *Pittsburgh Plate Glass*

534. Abrasives

New catalog covering SAE specifications on all types of abrasive shot, grit and cut wire. Methods and advantages of shot peening and impact cleaning, and the proper abrasive mixtures. *Cleveland Metal Abrasive*

535. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

536. Alloy Steel

68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

537. Alloy Steels

Article on use of chromium-molybdenum-vanadium steel for service at elevated temperatures. Chemical composition, mechanical properties. *Vancoram Review*, V. 13, No. 1. *Vanadium Corp.*

538. Aluminum Casting Alloys

8-page bulletin on aluminum casting alloys. Properties; selection of casting method; pig, ingot and billet compositions. *Metals Div., Olin Mathieson Chemical Corp.*

539. Aluminum Die Castings

Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

540. Aluminum Extrusions

Folder lists alloys used, finishes, trade phraseology. *General Extrusions*

541. Ammonia

8-page booklet on uses of dissociated ammonia in industry. Dissociation process and applications in bright annealing, furnace brazing, powder metallurgy, bright hardening. *Armour Ammonia*

542. Ammonia

69-page data book on anhydrous ammonia and ammonia liquor. Chemical and physical properties, specifications, analytical procedures, bibliography. *Nitrogen Div.*

543. Atmosphere Cooling

Bulletin T-40 on automatic heat treating units with controlled atmosphere cooling. *Ipsen*

544. Atmosphere Equipment

Bulletin No. I-101 on carbon dioxide removers. Design features, data chart, operation. *C. M. Kemm*

545. Beryllium Copper

New data sheets on three copper beryllium alloys. Analysis, physical constants, mechanical properties, heat treating procedures. *Pennrold Div., Brush Beryllium*

546. Beryllium Oxide

12-page booklet on properties, chemical analysis and applications of UOX beryllium oxide, a sinterable grade of refractory oxide of beryllium. *Brush Beryllium*

547. Blast Cleaning

12-page booklet on blast cleaning equipment describes vacuum-cast heat treated steel abrasive. *Pangborn*

548. Brazing

Brazing News No. 79 tells of silver brazing's characteristics. Case histories. *Handy & Harman*

549. Brazing Alloys

Standard compositions, specifications for high-purity brazing alloys for copper, bronze, brass. *Alloy Specialties*

550. Carbon and Graphite

Catalog Section S-5008 on carbon and graphite products for chemical operations includes heat exchangers, pumps, pipe and fittings. *National Carbon*

551. Casting Alloys

Compact, 28-page guide to nickel-containing casting alloys gives properties, compositions, uses of major alloys. *International Nickel*

552. Castings

New catalog on forging and casting products contains information on air hardening, oil hardening and other cast-to-shape tool steel specialties. *Allegheny Ludlum*

553. Castings

Data on castings of aluminum, magnesium and ductile iron for shock resistance. *Morris Bean & Co.*

554. Castings

Brochure on plaster mold castings of brass, bronze, aluminum, beryllium copper. *Ohio Precision Castings, Inc.*

555. Centrifugal Castings

16-page brochure on use and specifications of centrifugally cast cylinders, other products. *Sandusky Foundry & Machine*

556. Chromate Finishing

File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

557. Chromium Stainless

12-page book on fabrication and use of Type 430 stainless steel. *Sharon Steel*

558. CO₂ Welding

New 38-page booklet on inert-gas-shielded-arc welding of mild steel and low alloy steels with carbon dioxide shielding gas. *Hobart Bros.*

559. Coatings

4-page catalog on heat-proof protective coatings. Basic types, applications, methods of applying and temperature ranges. *Markal Co.*

560. Cold Forming

4-page folder on die-form process for cold reduction of steel bars into multi-

diameter shaft blanks for finish turning or grinding. *Republic Steel*

561. Cold Rolling

Description of advantages of cold rolling of ship propeller shafting. How it is done. *Erie Forge & Steel*

562. Compressors

12-page Bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

563. Controller

12-page bulletin on new impulse-sequence time-cycle controller and its uses. *Bristol Co.*

531. Stainless Wire

Starting with a general description of the rust-resisting, acid-resisting and heat-resisting steels, this 77-page booklet then goes on to give the analyses and properties of the austenitic, ferritic and martensitic stainless steels with special



emphasis on the properties produced by cold drawing. Many charts and tables present data in an easy-to-use form. The last half of the booklet pictures and discusses the hundreds of applications of cold drawn stainless steel wire. *Uddeholm Co. of America*

564. Controllers

Data on controllers and recorders. *Samuels Sons Iron & Steel Co.*

565. Copper Alloys

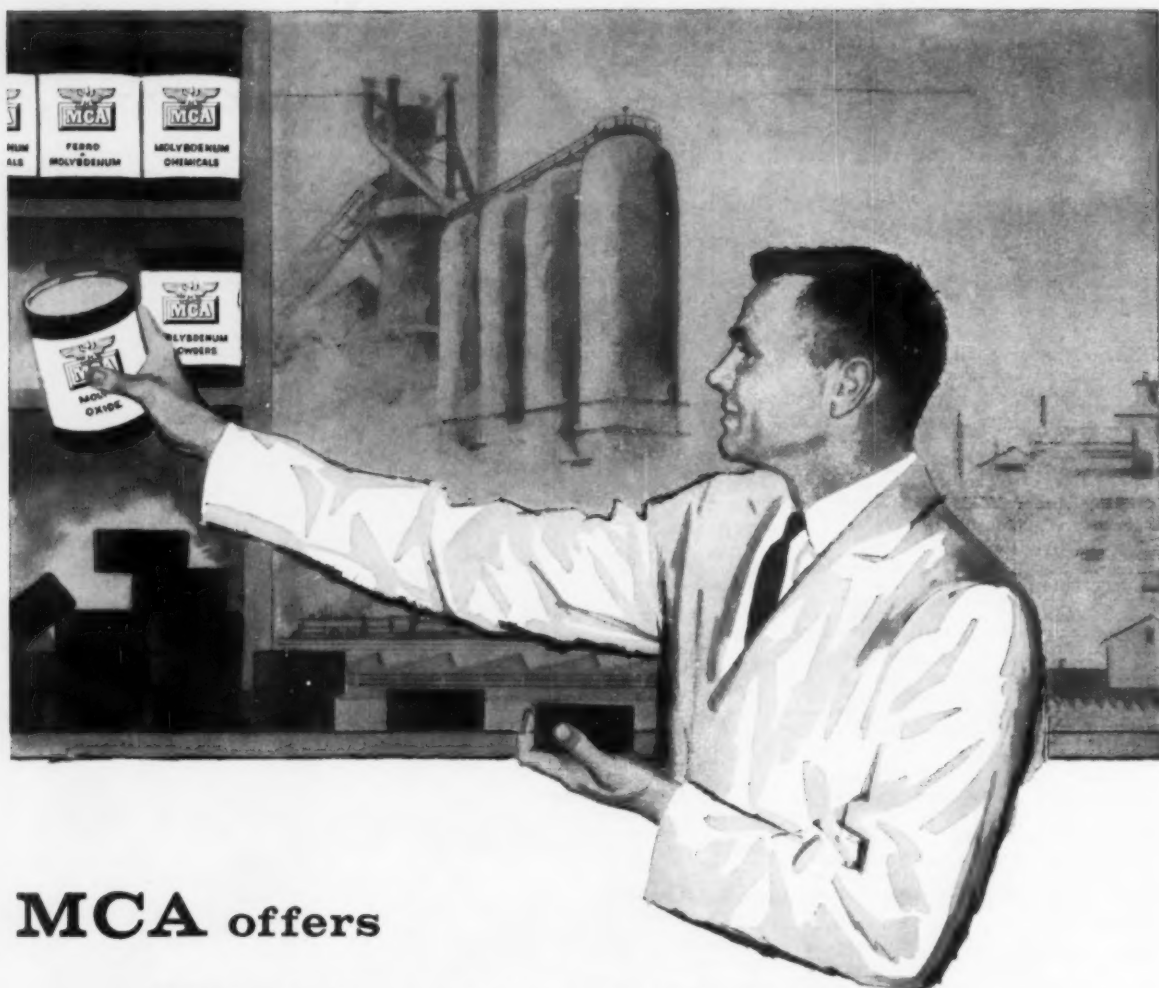
28-page specification index compares trade names and specifications of various agencies. Compositions of alloys. *American Brass Co.*

566. Cutting Oil

Folder describing nine types of cutting oils for varied applications. *Gulf Oil Corp.*

567. Cutting Tools

4-page Bulletin CT-175 gives specifications and descriptions of hack saw blades, hole saws, band saw blades. *Armstrong-Bloom Mfg.*



MCA offers

Molybdenum in all its forms

Molybdenum is widely accepted in the iron and steel industry, because it imparts improvements in physical properties at costs that may be economically justified. Such properties are effective both in economy of production and user benefits. In high speed steels, automotive steels, in aircraft and missile steels, molybdenum by MCA performs to meet designer's requirements.

This expanding use of molybdenum has resulted in demand for various forms—chemicals, metal powder, metallic

molybdenum and molybdenum oxide. MCA offers molybdenum in all commercial forms for easy and practical application in the mill. In addition, MCA's technical knowledge is unsurpassed and is available to the iron and steel maker upon request, free of charge.

When you have a metallurgy problem that molybdenum might solve, think first of MCA. When you need molybdenum in any form or quantity, MCA has it available for your use in iron and steel improvement.

MOLYBDENUM

2 Gateway Center

CORPORATION OF AMERICA

Pittsburgh 22, Pa.

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco
Sales Representatives: Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.



568. Deburring

2-page data sheet on chemical solution for removing burrs raised by drilling or other diecasting operations. *MacDermid, Inc.*

569. Degreaser

Folder on automatic degreaser. Cleaning and solvent cycles described. Features of equipment. *Detrez*

570. Degreasers

Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

571. Degreasing

Booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

572. Degreasing

Bulletin No. 70 on degreasing with trichlorethylene. Advantages and disadvantages. *Hooker Electrochemical*

573. Descaling

Bulletin 609 describes line of descaling machines, equipment, processes for metal cleaning. *Pangborn*

574. Die Steel

Folder and stock list on Olympic FM air hardening, high carbon-high chromium die steel with sulphide additives for improved machinability. *Latrobe Steel Co.*

575. Ductile Iron

Bulletin on magnesium ferrosilicon for ductile iron. Analysis of magnesium ferro alloys. Role of magnesium in ductile iron. *Union Carbide Metals*

576. Electric Furnaces

8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Pereny*

577. Electric Heat

New Bulletin GER-1333 on electric heat for plating baths. Installation, power and maintenance. *General Electric*

578. Electron Microscope

20-page brochure describes ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

579. Electroplating

Chart gives reference data for gold, rhodium, palladium, platinum, silver, nickel plating. *Technic*

580. Environmental Testing

New folder on temperature-humidity chambers, from 2 cu. ft. portable to 10 cu. ft. production model. *Harris Refrigeration Co.*

581. Extrusions

Bulletin on extruded seamless alloy and stainless steel tubing. Properties, shapes. *Metals Processing Div., Curtiss-Wright*

582. Finish

Data on production finishes for grinding, polishing and deburring of flat work. Specifications. *Hammond Machinery Builders*

583. Finish

New 4-page folder on heat-resistant coating. Properties, performance data on black and aluminum Sicon coatings. *Midland Industrial Finishes Co.*

584. Finishing

Bulletin on Unichrome coating 6400, a vinyl coating with the appearance of leather. Coating procedure. Advantages. *Metal & Thermit*

585. Finishing Processes

30-page catalog describes types and processes of finishing. Machines, accessories, applications. *Roto-Finish Co.*

586. Flame Hardening

New 4-page catalog on flame hardening

steels, cast iron, nodular iron. Parts flame hardened. Hardnesses produced. *Chicago Flame Hardening Co.*

587. Flow Meters

Catalog on flow meters for gases, liquids and combinations. Also line of manometers. *Seico Div., Eclipse*

588. Flow Meters

Bulletin 203 on flow meters for gas used in heat treating. *Waukeeng Eng'g.*

589. Forgings

Bulletin on forge steelmaking, open die forging, machining, heat treating and finishing. *National Forge*

590. Forgings

Folder on facilities for production of flat-die forged products. Electronic equipment used. *Smith-Armstrong*

591. Formed Plate

Bulletin on stainless steel ASME and standard flanged and dished heads. 352 available dies listed. *G. O. Carlson*

592. Formed Shapes

Catalog No. 1053 describing numerous formed shapes made from ferrous and nonferrous metals. *Roll Formed Products*

593. Freezer

Data on chest for use down to -140° F. for production and testing. *Revco*

594. Furnace

Bulletin 5709 on vacuum heat treating furnace. Temperature range 600 to 2150° F. Design features, performance data and applications. *C. I. Hayes*

595. Furnace

6-page Bulletin No. 805 on laboratory vacuum furnace. Specifications, applications, accessories. *Kinney Mfg.*

596. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

597. Furnace Controls

Bulletin 658 on saturable reactor for regulation and control of electric ovens and furnaces. *Sorgel Electric Co.*

598. Furnace Fixtures

16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood*

599. Furnaces

Bulletin No. 461 on gas, oil and electric furnaces. 17 different installations described. *Electric Furnace*

600. Furnaces

List of industrial furnaces and equipment in stock. *TherMaTek Co.*

601. Furnaces

8-page bulletin on pit-type convection furnaces. Uses, construction, atmospheres, specifications. *Hevi-Duty*

602. Furnaces

Bulletin 200 describes complete setup for heat treatment of small tools, including draw furnace, quench tank and high-temperature furnace. *Waltz Furnace*

603. Furnaces

12-page catalog on electric heat treating furnaces. Data on each of 57 models. Controls, instruments, elements and accessories. *Lucifer Furnaces, Inc.*

604. Furnaces

List of used furnaces in stock. *Papesch & Kolstad, Inc.*

605. Gas Analyzers

20-page booklet on continuous analyzers for combustible gases. Alarm systems. *Mine Safety Appliances Co.*

606. Gold Plating

8-page brochure gives bath composition, equipment and operating conditions, and metallurgical characteristics of 24K

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gold plate on various base metals. *Sel-Rez Corp.*

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6-page folder describing graphite electrodes for electric furnaces. Stock list of threaded graphite electrodes and their corresponding nipples. *Great Lakes Carbon*

608. Hardness Numbers

Pocket-size table of Brinell hardness numbers. *Steel City Testing*

609. Hardness Tester

Bulletin TT-59 on tester for measuring standard Rockwell and superficial hardness. *Wilson Mechanical Instrument*

610. Hardness Tester

Bulletin F-1689-3 on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

611. Hardness Tester

Bulletin S-33 on vertical-scale and dial-indicating scleroscopes. How they are calibrated. *Shore Instrument*

612. Hardness Tester

Catalog 72-1 on Leitz miniloader tester for Vickers and Knoop hardness tests. *Opto-Metric Tools, Inc.*

613. Hardness Tester

Bulletin on Brinell tester with test head for deep and offset testing. *King Tester*

614. Hardness Testers

Folder on portable hardness testers for testing of various sizes, shapes and types of metal. *Newage Industries*

615. Hardness Testers

26-page booklet on special Rockwell hardness testers such as motorized and internal testers, and accessories. *Wilson Mechanical Instrument Div.*

616. Hardness Testing

Bulletin A-18 on Alpha Co. Brinell hardness testing machines. *Gries Industries*

617. Heat Treat Pots

Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion*

618. Heat Treat Pots

6-page folder gives stock shapes and sizes. Tips on installation and use. *Electro-Alloys Div.*

619. Heat Treating

Folder on shaker-heartn furnaces and push-through muffle furnaces for annealing, hardening and brazing stainless steel. *American Gas Furnace Co.*

620. Heat Treating

8-page bulletin on heat treating. Data sheets on processes and processing equipment. Also covers annealing, brazing and hardening. *Ferrotherm*

621. Heat Treating

Monthly bulletin on used heat treating and plating equipment available for immediate delivery. *Metal Treating Equipment Exchange*

622. Heat Treating Dies

Article in Heat Treat Review, Vol. 10, No. 1 on heat treating of precision dies. *Surface Combustion Corp.*

623. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

624. Heat Treating Fixtures

16-page Catalog M-7 on heat treating baskets and corrosion-resistant-alloy fabrications. *Wiretex Mfg. Co.*

625. Heat Treating Furnaces

42-page catalog on line of furnaces and ovens for heat treating and accessory equipment. *K. H. Huppert Co.*

626. Heat Treating Guide

Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

627. Heat Treatment

4-page bulletin on a home study and in-plant course on heat treatment of steel. *ASM Metals Engineering Institute*

628. Heating

Bulletin on Heat-O-Coil resistance wire for preheating and stress relieving. *Arco Corp.*

629. Heating Elements

12-page bulletin gives typical applications of silicon carbide heating elements. Hints on handling, unpacking, storage, installation, replacement. *Glober Div., Carborundum*

630. Heating Elements

24-page booklet on elements for electric furnaces and kilns includes technical data, uses, physical and electrical specifications. *Norton*

631. High-Strength Steel

26-page booklet on properties, uses, applications of high-tensile low-alloy steel. *Jones & Laughlin*

632. High-Strength Steel

24-page bulletin on steel bars made by elevated temperature drawing. Strength without heat treatment, machining, wearability. *LaSalle Steel*

633. High-Temperature Properties

Metallurgical facilities for elevated temperature mechanical properties evaluation. Pocket-size circular slide rule. *Joliet Metallurgical Laboratories*

634. Induction Heaters

12-page bulletin gives descriptions,

technical data on various sizes. Water systems diagramed, standard accessory equipment. *High Frequency Heating Div., Lindberg Engineering*

635. Induction Heating

8-page bulletin on high-frequency motor-generator sets for induction heating. *Ohio Crankshaft*

636. Industrial Furnaces

Folder on batch, automatic, continuous gas, electric and oil furnaces. Selection chart shows which operations may be performed in which type of furnace. *Sunbeam Equipment Corp.*

637. Inspection

Bulletin on Spotcheck dye-penetrant inspection. Advantages, prices. *Magna-flux*

638. Inspection

Data on ultrasonic inspection and thickness measurement service in field or laboratory. *Sperry Products*

639. Insulating Firebrick

8-page Bulletin R-43 gives description of relationship between heat losses and weight of refractory lining. *Babcock & Wilcox, Refractories Div.*

640. Insulators

Bulletin PI-55 on insulators and insulating tubing. *McDaniel Refractory Porcelain*

641. Investment Casting

"Pointing the Way" presents seven case histories on advantages of investment castings. *Engineered Precision Casting Co.*

642. Laboratory Equipment

Bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

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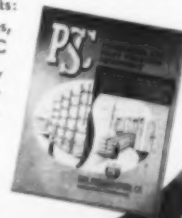
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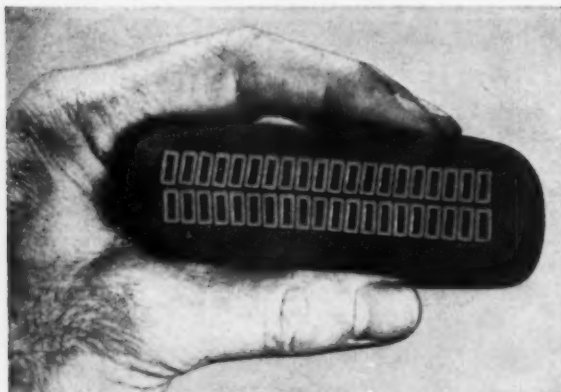
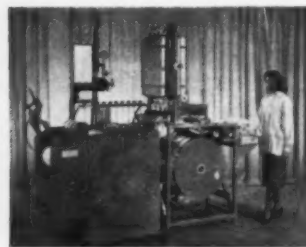


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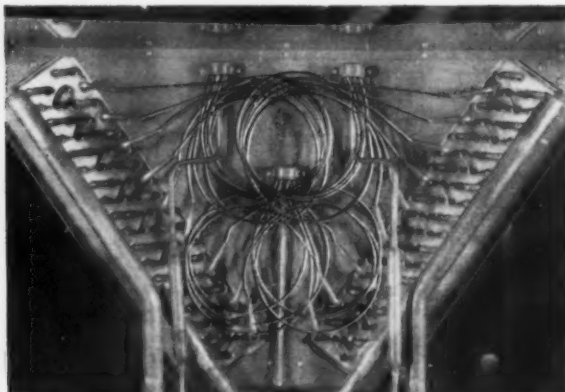
BETTER WAYS of doing things with seamless copper tube are unlimited—from capillary sizes to 26-inch diameter—round tubes or special shapes.



A better product faster. In the Kodak Roll Paper Dryer-Glazer shown below, photographic print paper travels around a heated, mirror-smooth, chromium-plated copper drum. This drum could be formed from sheet metal, welded and ground. But Eastman Kodak Company takes a production short cut and buys the drums ready made—Anaconda seamless copper tube 26" inside diameter, in wall thicknesses of $\frac{1}{8}$ ", cut to 20" lengths. Having the thermal conductivity and corrosion resistance needed, the tube is also easy to polish to a high mirrorlike finish (photo, left), provides an excellent base for fine chromium plating. No seams mar the surface. Production time and steps are cut.



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643. Laboratory Furnace

Data on nonmetallic resistor furnaces for research, testing or small-scale production. Harrop Electric Furnace

644. Laboratory Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. Marshall Products

645. Lead Steels

16-page booklet on basic characteristics, mechanical properties and workability of lead steels. Case histories. Copperweld Steel Co.

646. Lubricant

Bulletin 426 on use of colloidal graphite for forging, wire drawing, piercing, drawing, extrusion and other metalworking operations. Acheson Colloids

647. Malleable Iron

New Data Unit No. 102 on importance of tensile strength, yield strength, fatigue strength and other strength factors, especially as applied to malleable irons. Malleable Castings Council

648. Manganese

Technical Data Bulletin 201 on electro-manganese and nitrelmang. Product characteristics. Composition. Foote Mineral

649. Marking

Data on Paintstik markers for identification of heat treated parts. Markal Co.

650. Marking Machines

Bulletin 146-C25 and 146-C26 on complete line of marking machines, stationary and portable. For polished surfaces, precision finished parts, glass, ceramics. Jas. H. Matthews

651. Meehanite Castings

12-page booklet on castings for cams, camshafts and crankshafts describes specific applications. Meehanite Metal

652. Melting

Bulletin 14-B on high frequency furnaces for melting ferrous and nonferrous alloys. High temperature applications up to 3600° C. Ajax Electrothermic Corp.

653. Metal Cleaning

32-page Bulletin 10,001-G on methods, materials and equipment for cleaning and preparing metal surfaces. Magnus Co.

654. Metal Cleaning

Folder lists products for immersion, electrolytic, spray cleaning, other cleaning agents. Northwest Chemical

655. Metal Cutting

56-page Catalog No. 32 gives prices and describes complete line of rotary files, burs, metalworking saws and other products. Martindale Electric

656. Metal Marking

Bulletin on all-purpose electric pen which will etch any metal. Newage

657. Metal Powders

New 8-page brochure gives information on prealloyed metal powders and tool steels used in powder metal parts production. Vanadium-Alloys Steel Co.

658. Metal Sorting

Data on nondestructive sorting of raw, semifinished or finished parts. J. W. Dice

659. Metallograph

Bulletin on metallograph operated from sitting position. Transitions are instantaneous. Accessories are interchangeable. Wm. J. Hacker

660. Microhardness Tester

Bulletin describes the Krypton microhardness tester. Torsion Balance

661. Microscope

Technical Bulletin HHS-2 on vacuum heating stage which permits specimens to be examined at temperatures ranging

(Continued on page 48-A)



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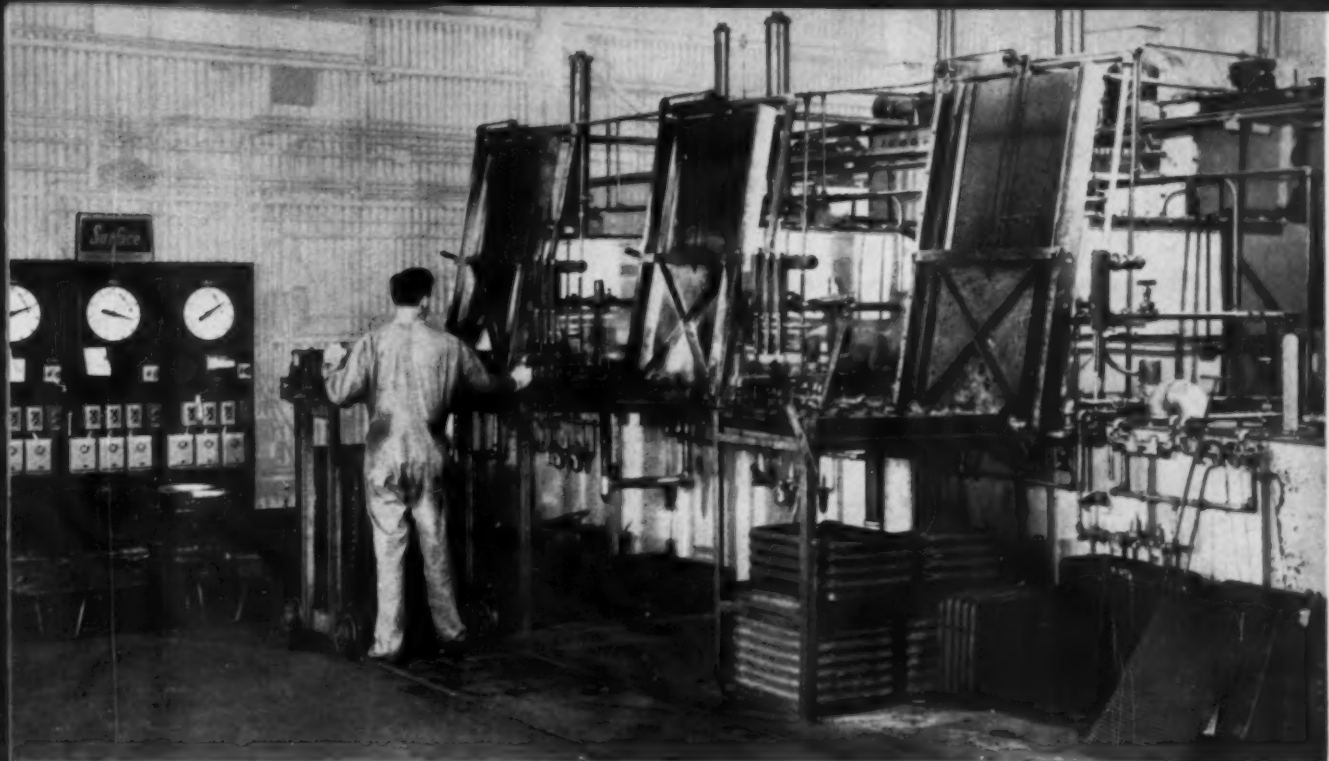
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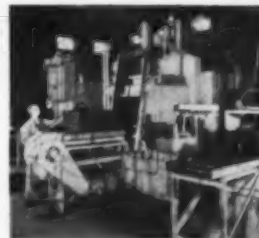
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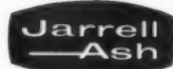
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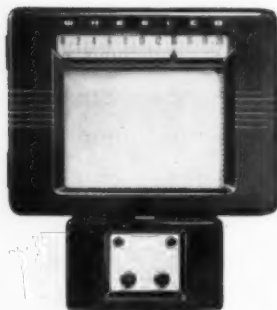
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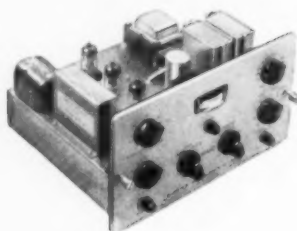


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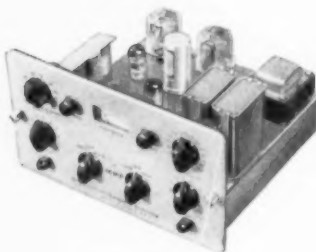
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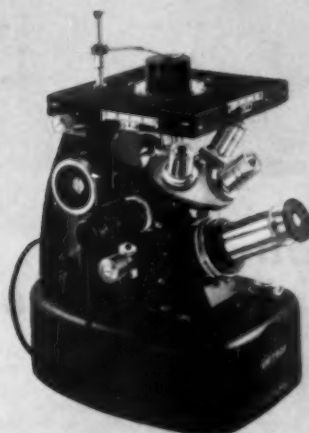
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These typical 25 took a total of 152



MODEL MEC

UNITRON INVERTED Metallurgical Microscope: This compact unit provides many of the features usually found only in larger metallographs. Standard equipment includes optics for 25-1500X, polarizers, filters, transformer in base, etc. A built-in camera attachment for 35mm. photography is included with the binocular and available for the monocular model. Extra accessories include Polaroid camera attachment, vacuum heating stage and illuminator for transmitted light. Think of the time which your laboratory can save by providing each metallurgist with one of these handy, inexpensive units for use at his desk.

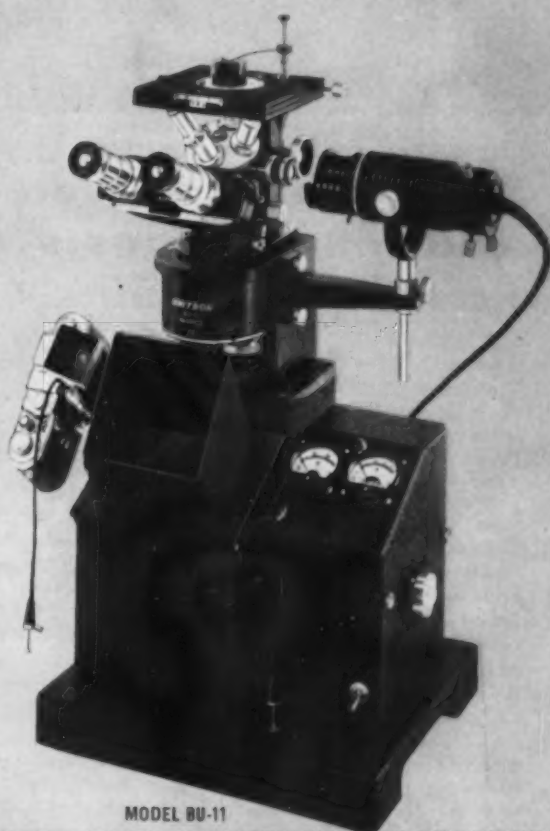
Monocular Model MEC \$399

Binocular Model BMEC \$615

UNITRON METALLOGRAPH and Universal Camera Microscope: A completely self-contained instrument of modern design for visual observation, photography, projection, and measurement of both opaque and transparent specimens; using bright field, dark field, or polarized illumination. Standard equipment includes all optics for 25-2000X, polarizers, filters, 3 1/4" x 4 1/4" camera, and many accessories. Also available are camera attachments for Polaroid, 35mm., and motion picture photography; vacuum heating stage for temperatures to 1500° C.; and macro-objectives (5-40X). Even laboratories on a limited budget can enjoy the precision, speed and efficiency possible only with a complete installation of this type.

Monocular Model U-11 \$1195

Binocular Model BU-11 \$1379



MODEL BU-11

There is a free 10 day trial offer on any UNITRON Microscope.

Let the instrument prove its value to you—in your own laboratory—before you decide to purchase.

See for yourself why...

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SEND FOR YOUR FREE CATALOG. IT'S YOURS FOR THE ASKING ▶

UNITRON INSTRUMENT DIVISION
OF UNITED SCIENTIFIC CO.
204-206 MILK STREET, BOSTON 9, MASSACHUSETTS

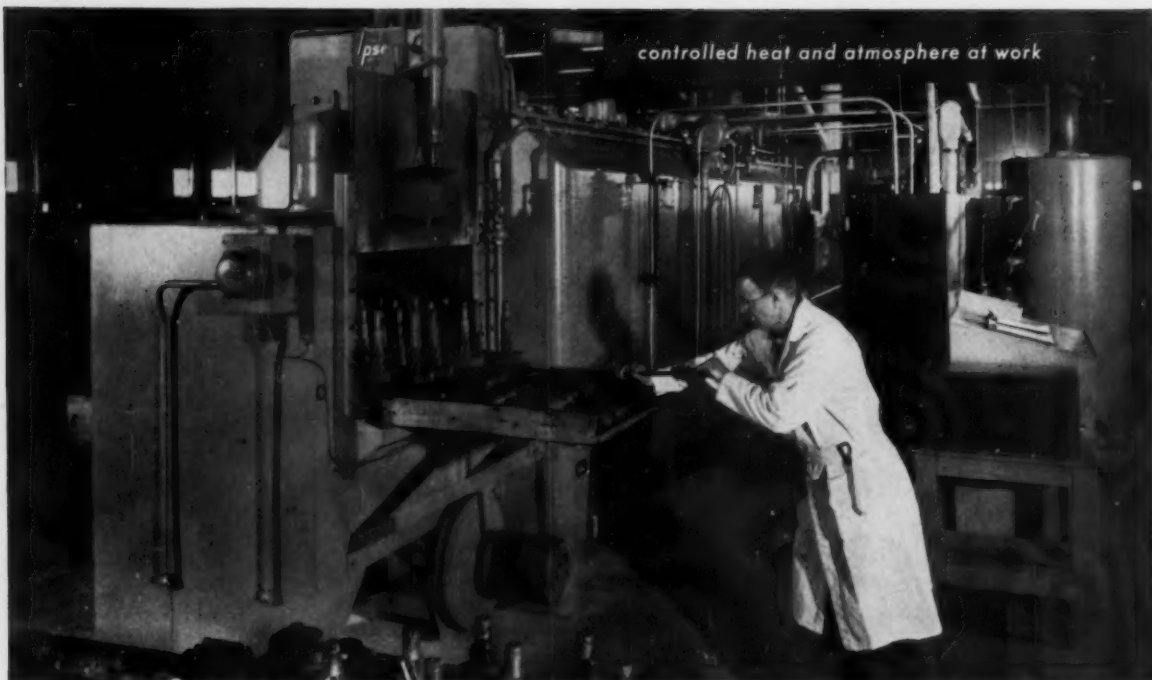
Please rush UNITRON'S Microscope Catalog 2-U

NAME

ADDRESS

CITY

STATE



Le Tourneau-Westinghouse Company uses this Ipsen "straight-through" controlled atmosphere, semi-automated pusher furnace for hardening final drive gearing and transmission parts used in Le Tourneau-Westinghouse earth moving equipment.

"...we've increased production 25% and reduced costs with our Ipsen pusher heat treating units."

Le Tourneau-Westinghouse Company, Peoria, Illinois

Harold C. Stone is Chief Metallurgist of Le Tourneau-Westinghouse Company, Peoria, Illinois, one of America's leading producers of earth moving equipment. In the following interview, Mr. Stone tells why he is well satisfied with his Ipsen controlled atmosphere pusher heat treating equipment.



Q. What type of work do you run in your Ipsen "straight-through" controlled atmosphere heat treating unit?

A. We use our Ipsen pusher equipment for the controlled atmosphere hardening of final drive gearing, transmission parts, and other parts used in our Le Tourneau-Westinghouse earth moving equipment. Every 15 minutes the furnace receives a 200-lb. charge which remains in the furnace 90 minutes, and in the quench 10 minutes. If necessary, we can increase our charges to 500

lbs. and heat treat 2000 lbs. per hour.

Q. Have you been able to increase production with your Ipsen equipment?

A. We have achieved an approximate 25% increase with our Ipsen unit (as compared with the four salt pots it replaced). Part of this improvement is due to the fact that our work is pushed through the furnace work chambers, and quench, automatically. This, of course, is faster than would be possible if it had to be handled by our operators.

Q. What about your operating or production costs?

A. Fuel costs have definitely been reduced. Gas consumption with our Ipsen unit (including the generator) is less than 1,000 cfh...as compared with a total of 2,000 cfh for the four pot furnaces which turn out less work. Straightening, which was formerly required on about 80% of our parts with long shafts, has been virtually eliminated. And

sand blasting is no longer necessary.

Q. What do you think of the automatic quench feature of your Ipsen equipment?

A. We like it because we can set the temperature of the quenching medium and maintain it. As a result, we obtain better quality and less distortion. We save labor by quenching batches instead of individual pieces.

Q. What about maintenance?

A. We haven't had any maintenance to speak of...only routine and preventive maintenance.

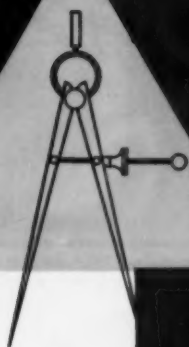
Q. Have your men commented on Ipsen equipment?

A. Yes. Our heat treat foreman, Mr. Waldo Dirkes, says it's one of the nicest pieces of equipment we have. He says the pusher furnace is simple to operate and certainly easy to keep clean.

Ask for your copy of a brochure describing the type of Ipsen equipment used by Le Tourneau-Westinghouse.



IPSEN INDUSTRIES, INC. • 723 S. MAIN STREET • ROCKFORD, ILLINOIS



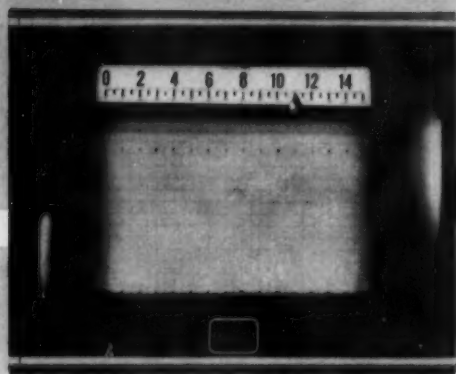
and now...

MEL-TROL

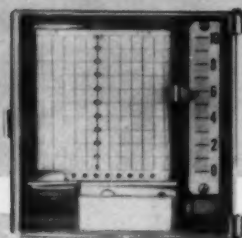
vega (A.I.S.I. Type A6)

gives you deeper hardening, less sensitivity to overheating, greater protection against size change and distortion, greater toughness than competitive air-hardening steels such as A4. And now, produced to MEL-TROL standards, Vega gives you the greatest plus of all—maximum uniformity from surface to core, end to end, lot to lot. Vega combines the machining properties and simplicity of low temperature heat treatment of many oil-hardening grades with safety in hardening of an air-hardening steel. Get immediate delivery from your local Carpenter SERVICE-CENTER.

the *Carpenter* Steel Company, Reading, Pa.



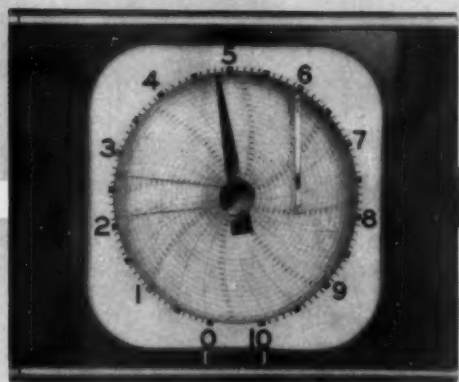
Dynamaster Electronic Potentiometer Pyrometer—Strip-chart model records on chart 11" wide, 120' long.



Miniature Electronic Dynamaster Pyrometer—Records on 3" strip-chart. Indicator model features easy-to-read 9" scale length.



Bristol Millivoltmeter Pyrometers—Free Vane® pyrometer controllers (shown) or indicating types. Many control modes available.



Dynamaster Electronic Potentiometer Pyrometer—Round-chart model records on 12" chart, indicates on extra large scale.

MODERN PYROMETERS...key to profitable use of HEAT

Bristol recording and automatic controlling pyrometers for temperatures up to 5000°F can help you increase product uniformity, cut fuel and maintenance costs

Bristol makes a wide range of pyrometers for every requirement: Electronic potentiometers, millivoltmeter and radiation types . . . for furnaces, ovens . . . every type of heating equipment, every kind of fuel. The reliability and accuracy of these precision instruments have been proved in thousands of installations.

Take just one advanced Bristol instrument, for example, the Electronic Dynamaster® Potentiometer Pyrometer:

CONTINUOUS STANDARDIZATION PLUS ACCURACY OF STANDARD CELL

Continuous standardization in Dynamaster Electronic Pyrometers requires no dry-cells, but still retains the precision standard cell for highest stability and accuracy of voltage reference. Results: No interruption to operation, no batteries to change. And here are just a few of the Dynamaster types available:

A model for every requirement: Dynamaster Pyrometers are available as single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments and as round-chart instruments.

Electric and pneumatic controllers: Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control—on-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control—on-off, proportional, and proportional with reset.

Miniature Dynamaster Pyrometer: Full plug-in flexibility . . . takes only 5" x 5½" of panel space, but has same basic accuracy, same time-tested operating principle as full-size Dynamaster pyrometers described above. Ideal for graphic panels and centralized recording or indicating of large numbers of variables. Either electrical or pneumatic control types available.

Write for complete data on Bristol Pyrometers—and remember Bristol offers a complete line of thermocouples and pyrometer accessories. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

*T.M. Reg. U.S. Pat. Off. ©

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



**Two 36-KW Controlled
Atmosphere Belt Conveyor
Furnaces used to heat treat
radio tube parts.**

- Belt Width — 12"
- Heating Chamber Length — 36"
- Variable Speed Drive — 3" to 24" per minute

Controlled Atmosphere **CONVEYOR furnaces**

Drever controlled atmosphere type furnaces are available in many designs to suit applications where high quality surface and heat treating specifications are essential. Belt conveyor furnaces are designed with and without muffles, electrically heated and/or fuel fired.

Excellent temperature uniformities, with complete automatic temperature controls are maintained within narrow limits up to 2100°F.

*We will be glad to supply you
with complete information*



RED LION RD. and PHILMONT AVE., BETHAYRES, PA.

HARBISON-WALKER

anticipates the refractories needs
of the expanding aluminum industry

Within the last couple of decades the production of aluminum metal in the United States has trebled and the number of its alloys has increased many-fold. Rapid evolutionary developments created the need for refractories to meet new conditions. The severity of corrosion, more destructive impact accompanying furnace charging and the necessity of avoiding contaminants in order to meet rigid alloy specifications—these among other factors have become increasingly important.

Since the first commercial production of aluminum and its alloys, Harbison-Walker brands, primarily of alumina-silica and high-alumina com-

positions, have continued to fulfill the ever-growing demands. Through unceasing research several refractories, recently developed specifically for aluminum melting furnaces, possess definitely superior properties for maximum durability and best quality of metal. Harbison-Walker's CORALITE XX (85% alumina brick) has established excellent service records in aluminum furnace bottoms and side walls. Several modifications with enhanced properties now are in commercial production. These unique refractories especially suited for aluminum melting furnaces are here briefly described.

Coralite 22-58
Coralite 3-59
CORALBOND

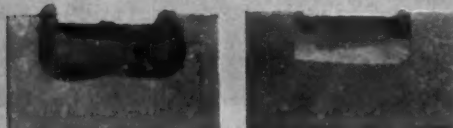
CORALITE 22-58 is a stabilized aluminum phosphate-bonded brick containing approximately 85% alumina. It has exceedingly high strength and withstands greater impact and abrasion. Its resistance to wetting and penetration by the molten metal are properties of paramount importance. CORALITE 24-59 is the hard-fired variation, having still higher mechanical strength.

CORALITE 3-59 is a very hard-burned brick containing approximately 85% alumina. It is made with a special bond (patent pending) which contributes to its remarkable strength. It is very resistant to penetration and reaction with molten aluminum.

CORALBOND is a phosphate bonded high alumina mortar developed specifically for use in aluminum melting furnaces. It is very outstanding in its resistance to penetration and corrosion by aluminum alloys at the furnace operating temperatures.

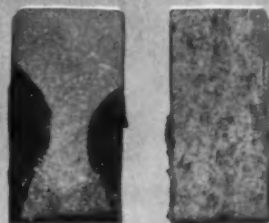
Laboratory
tests
illustrate
superior
properties

CUP TEST



Photograph of accelerated cup test with molten aluminum alloy—at 1700°F for 30 hours—showing relative degree of penetration between normal high alumina brick on the left and CORALITE 22-58 on the right.

IMMERSION TEST



These brick, which were immersed in aluminum alloy at 1400°F for nine days, show contrast in degree of penetration or wetting between a normal high alumina brick, left, and CORALITE 3-59, on the right.

Harbison-Walker

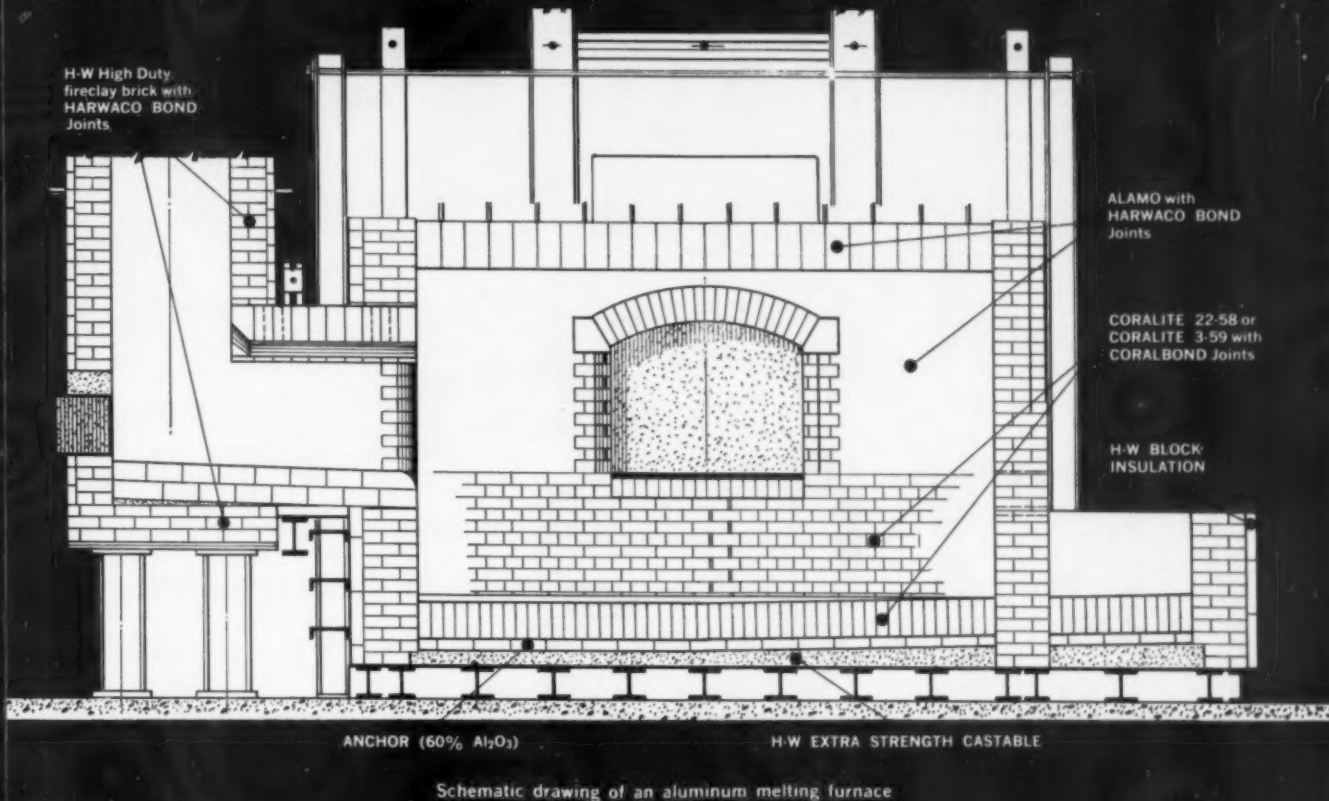
World's Most Complete Refractories Service

GENERAL OFFICES

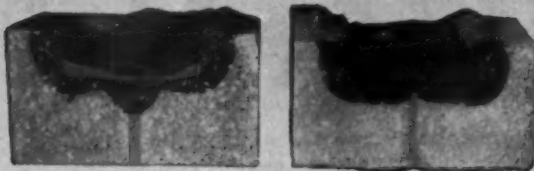
PITTSBURGH 22, PA.

METAL PROGRESS

RESEARCH



MORTAR JOINT TEST



Photograph of Laboratory "cup tests" with molten aluminum alloy, show striking difference in resistance to penetration and corrosion between a widely-used air-setting bonding mortar at the left and the CORALBOND joint at the right. Among many mortars of widely different compositions, CORALBOND—as illustrated in this test—is unmatched.

Leadership in Refractories Through Constant Research

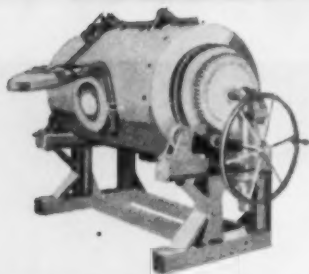


GARBER RESEARCH CENTER

Refractories Company
AND SUBSIDIARIES



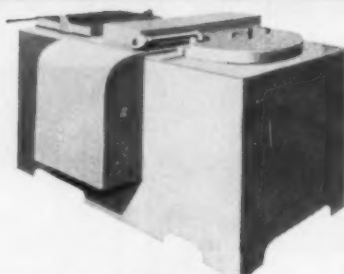
Wherever industry needs heat ... **There's LINDBERG**
equipment just right for the specific job



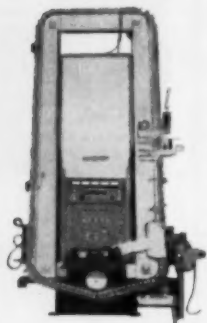
Rotary Open-Flame Smelting Furnaces: Lindberg-Fisher Simplex (shown) either oil or gas fired with capacities to 30,000 lbs. brass, 2,400 lbs. aluminum.



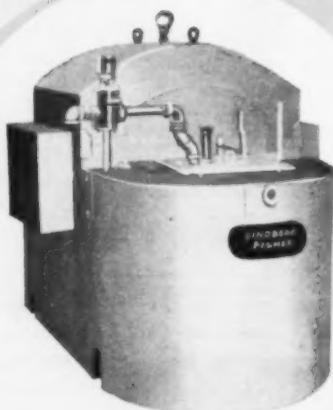
Automatic Lading Units: The Autoladle "Little Joe". The first practical automatic aluminum lading unit yet devised.



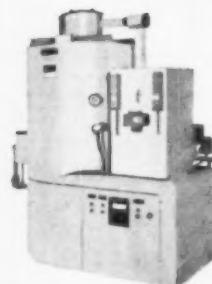
Induction Melting and Holding Furnaces: Lindberg-Fisher two-chamber furnace (shown) melts in one chamber, holds at correct temperature in other.



High Frequency Units: Vertically designed, completely automatic "HF" unit (Shown) for aluminizing automotive valves.



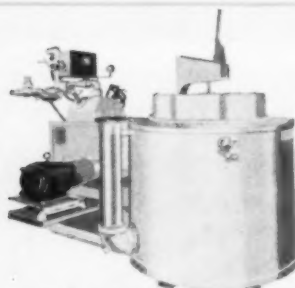
Melting and Holding Furnaces: Electric resistance furnace (shown) with capacities of 750 lbs. to 1500 lbs.



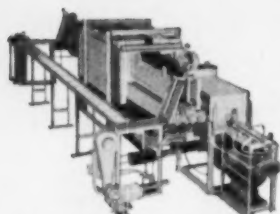
Atmosphere Generators: Hyen generator (shown) for endothermic atmospheres. Generators for all required atmospheres.



Pilot Plant Equipment: Atmosphere tube unit (shown) for ceramic research and development at temperatures up to 2750° F.



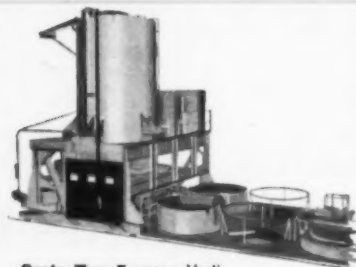
Cyclone Tempering Furnaces: Batch type fuel-fired tempering furnace (shown). Famous in metal treating industry for years.



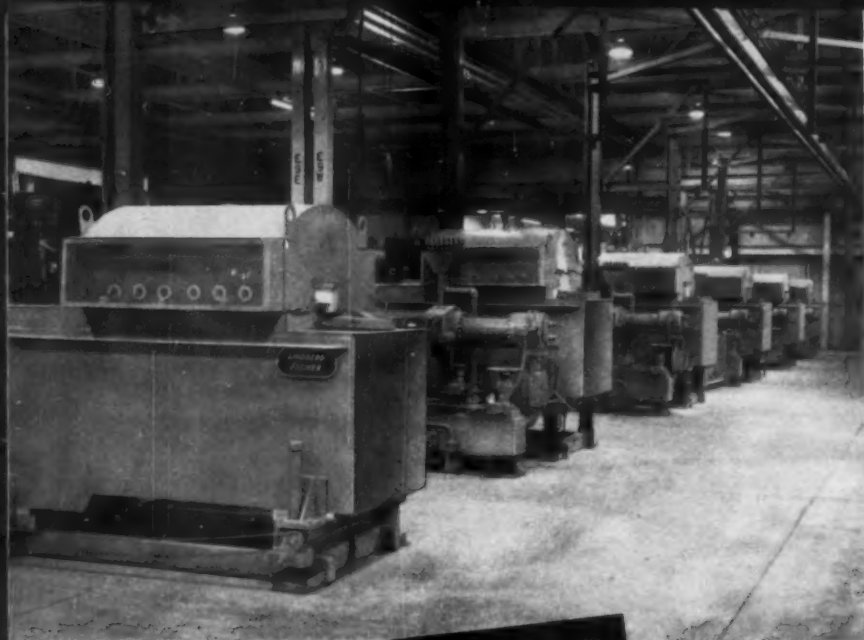
Ceramic Kilns: Fully automatic, atmosphere controlled kiln (shown) has 5 control zones for flexibility. Maximum temperature, 2700° F.



Aluminum Reverberatory Furnaces: Twin-chamber melting and holding furnace (shown) with 45,000 lbs. capacity.



Gantry Type Furnace: Vertical, controlled-atmosphere, drop bottom, hardening furnace. Complete installation field-installed by Lindberg.



Lindberg-Designed

**furnaces, more than 75 of them,
help Ford Motor Company maintain
casting production and quality standards**

The new Aluminum Castings Plant of Ford Motor Company, Engine and Foundry Division, at Sheffield, Alabama, is a model of modern production efficiency. Contributing to its effective operation is a huge battery of Lindberg-Fisher aluminum holding furnaces, more than 75 of them. Eight large 65,000 lb. capacity reverberatory holding furnaces receive molten aluminum delivered from an adjacent Reynolds Metals plant and hold it at the desired temperature. Six other reverberatory furnaces, each with 20,000 lb. capacity, are used for remelting scrap aluminum from trimmed parts and holding metal at its usable temperatures. Molten metal is then delivered to more than 60 electric resistance holding furnaces in the casting area as needed. This unique installation, developed by Ford engineers in conjunction with Lindberg, is a major factor in maintaining the high quality product and production standards required by Ford.

Lindberg equipment and Lindberg planning can help you find the most effective answer to any problem of applying heat to industry. We cover the field, melting and holding, heat treating, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend just the type of equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg-Fisher Division, Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.



Handsome entrance to new plant of Ford Motor Company, Sheffield, Alabama.



Metal temperatures are positively controlled through Lindberg Control Panel.



Some furnaces are arranged for hand lading and others are equipped with Lindberg Auto-ladle.



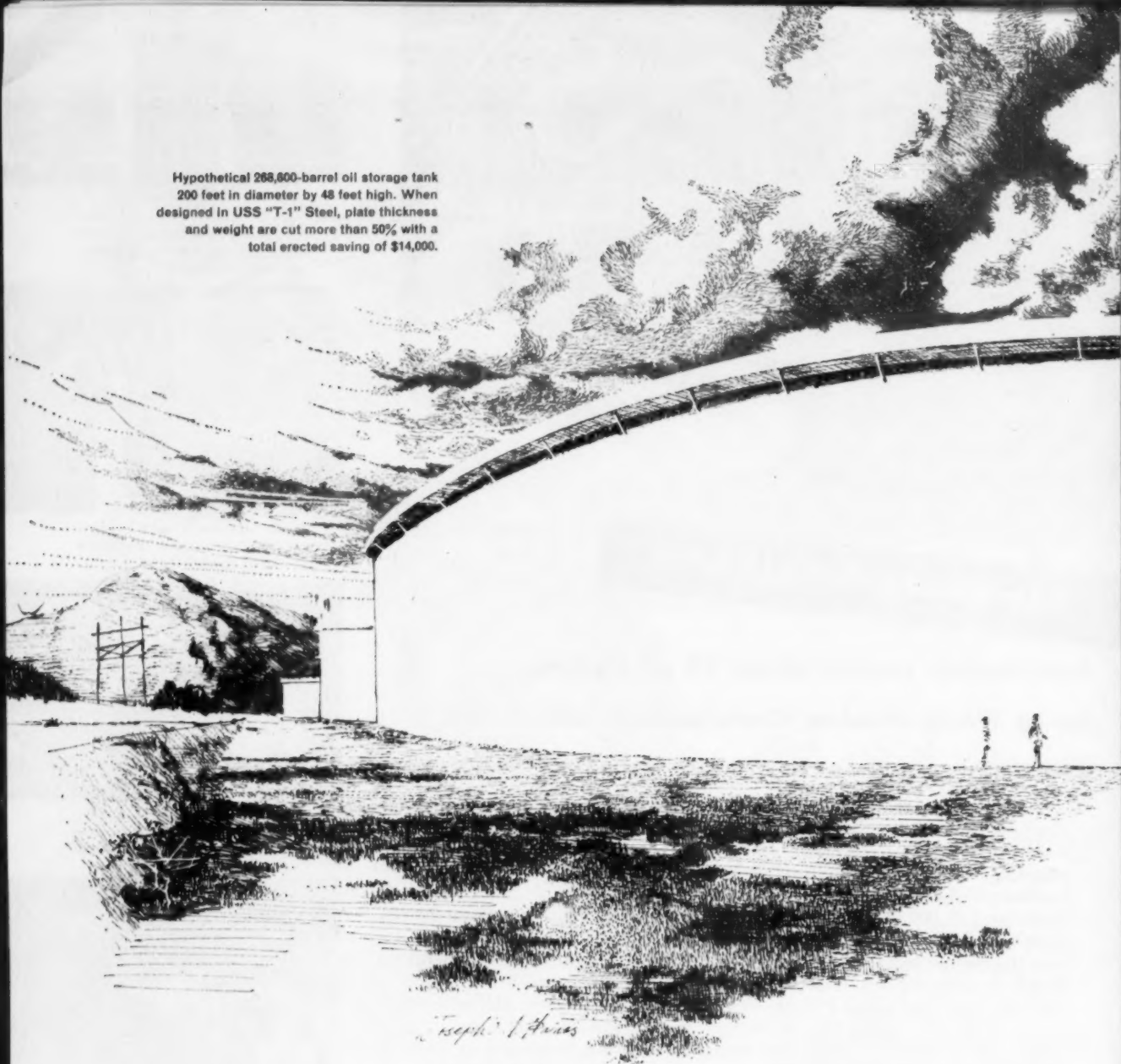
Molten aluminum is delivered direct to reverberatory holding furnaces.



The molten metal is held in these 14 huge furnaces for distribution to the casting areas.

LINDBERG heat for industry

Hypothetical 268,800-barrel oil storage tank
200 feet in diameter by 48 feet high. When
designed in USS "T-1" Steel, plate thickness
and weight are cut more than 50% with a
total erected saving of \$14,000.



Design Advantages of USS "T-1" Steel

The following thickness and cost figures result from comparing two designs for the tank—one using ASTM A283 structural carbon steel following API Standards, the other using USS "T-1" Steel at a higher design stress than permitted by API. Note, that although a higher unit stress is used with "T-1" Steel, an even higher safety factor on yield strength is obtained.

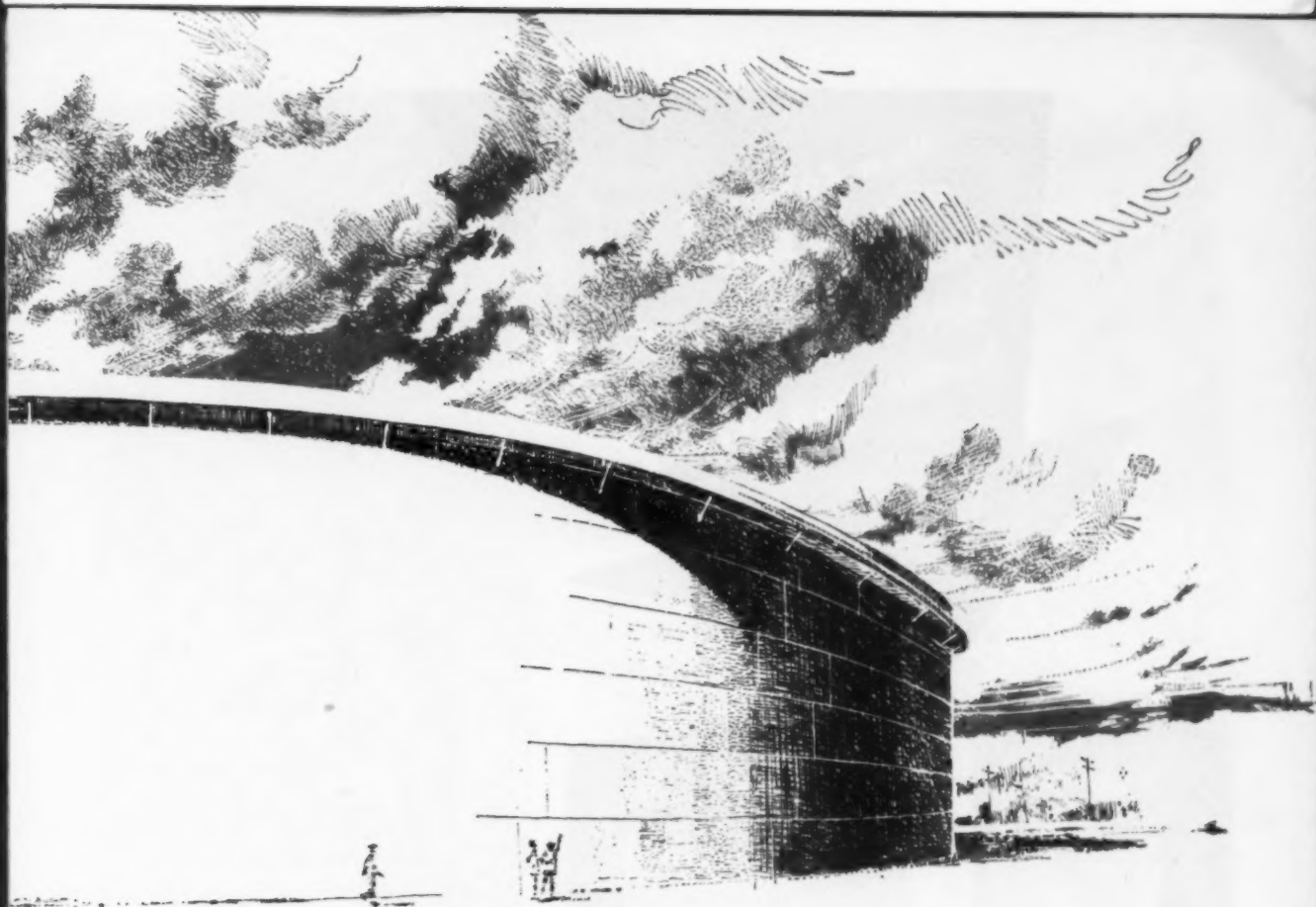
	USS "T-1" STEEL	ASTM A283 Carbon Steel
Yield Strength	100,000 psi	30,000 psi
Design Stress	50,000 psi	21,000 psi
Joint Efficiency	0.85	0.85
Working Stress	42,500 psi	17,850
Factor of Safety on Yield Strength	2.44	1.68

PLATE THICKNESSES COMPARED

	USS "T-1" STEEL	ASTM A283 Carbon Steel
Course No. 1	0.59"	1.37"
Course No. 2	0.49"	1.14"
Course No. 3	0.39"	0.91"
Course No. 4	0.3125"	0.67"
Course No. 5	0.3125"	0.44"
Course No. 6	0.3125" (A283 Steel)	0.3125"

How USS "T-1" Steel can reduce costs (compared with A283 Steel)

Material cost:	\$4,400 more
but	
Fabricating cost:	\$6,160 less
Freight cost:	\$4,930 less
Erection cost:	\$7,310 less
Overall savings with "T-1" Steel	\$14,000



\$14,000 can be saved by building this oil storage tank with "T-1" Steel

Here is a design for an oil storage tank that hasn't been built yet. It is 200 feet in diameter by 48 feet high. Capacity: 268,600 barrels.

The tank was designed by a well-known firm in this field —Pittsburgh-Des Moines Steel Co. The costs were estimated for both structural carbon steel to API standards and for building the tank with USS "T-1" Constructional Alloy Steel. In both cases, the bottom plates, roof plates and framing are all ASTM A283 carbon steel. The comparisons apply only to the shells.

USS "T-1" Steel construction costs less. As you can see from the chart, the total cost of the shell construction with USS "T-1" Steel is \$14,000 less than with carbon steel, although the cost of the steel itself is \$4,400 more. The big savings come from lower costs of fabrication, freight and erection. The reason for this is that USS "T-1" Steel's great strength (100,000 psi minimum yield strength) permits the plate thickness to be reduced more than 50% in most cases. The total steel weight is less, the thinner plates cost less to weld and ship, and fabrication costs are estimated to be lower.

Lower maintenance, too! USS "T-1" Steel has four times the resistance of carbon structural steel to atmospheric corrosion. Research has shown that paint life is extended on steels that have increased resistance to atmospheric corrosion; consequently, longer intervals between paintings is an added advantage of using USS "T-1" Steel.

Retains Toughness down to -50° F. USS "T-1" Steel's exceptional strength and toughness, even at very low temperatures, make it the ideal material not only for tanks, but for pressure vessels, equipment hauling trailers, offshore rigs and other equipment that must be built stronger but lighter. Write for a copy of our booklet, USS "T-1" Steel. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and "T-1" are registered trademarks

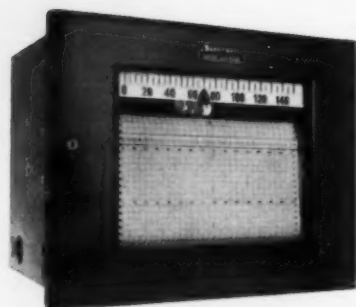
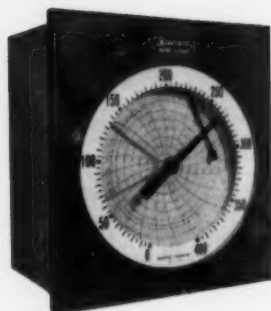


United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

New Constant
Voltage Unit
makes *ElectroniK*
instruments
better than ever

by eliminating
these
problems



All new Precision Line *ElectroniK* circular and strip chart instruments have the new Honeywell Constant Voltage Unit that accurately regulates d-c reference supply to the measuring circuit. No more batteries, standard cells or standardizing mechanisms . . . and no more of the problems they pose.

The Constant Voltage Unit delivers a constant, rectified voltage from line supply. It uses dependable Zener diodes and a reliable ambient temperature compensator.

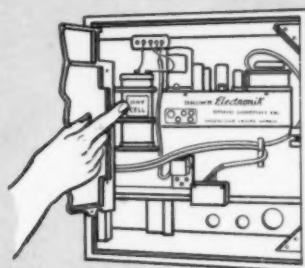
This latest improvement in *ElectroniK* instruments assures even greater dependability, and less maintenance, and is still another reason why *ElectroniK* instruments are your best value in measurement and control. Get full details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

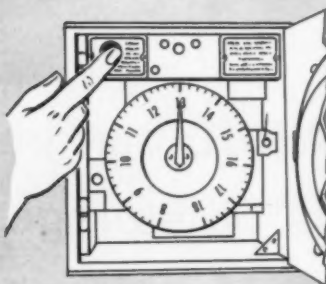
Honeywell



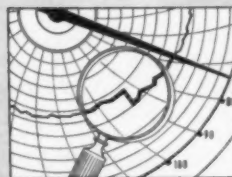
First in Control



No batteries to replace . . . no recording or control deviation due to low battery voltage.



No button to push on the instrument for standardization . . . no false readings because of failure to standardize.



No blanks or shifts in the instrument's response to variables. You get complete continuity of recording and control.

Finkl die blocks and forgings made of vacuum degassed steel*



REDUCE DOWNTIME

Finkl vacuum degassed steels result in die blocks, hot work die steels, and forgings with greater ductility and toughness. This means that size for size, and/or hardness for hardness, the degassed steel reduces the chances of breakage and excessive wear under severe operating conditions.



REDUCE MACHINING TIME

Finkl vacuum degassed steels are cleaner. About 50% of the nonmetallic inclusions have been removed. Machineability is improved, with higher lusters obtainable in die block impressions, if desired. Fewer tool regrinds are required.



ASSURE DELIVERY

Finkl vacuum degassed steels promote high density centers in large die blocks and forgings therefore reducing the possibility of late shipment because of ultrasonic rejection.



For over 80 years Finkl has been producing top quality products. Now with the introduction of vacuum degassing of our electric furnace steels we have the most complete control of quality which enables us to offer the finest in die blocks, hot work die steels and flat die forgings. Call your Finkl representative.

A. Finkl & Sons Co.

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Warehouses in: CHICAGO • DETROIT • BOSTON • LOS ANGELES

*To prevent corrosion
and anchor paint
on aluminum*

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS



Protect aluminum at lowest unit cost with CHROMICOAT[®] conversion coating

Oakite CHROMICOAT is an economy any way you look at it: on the basis of price alone . . . on solution make-up and "mileage" . . . on the way it blocks corrosion and forms a perfect anchor for paint to keep your customers sold and satisfied.

This is a conversion coating you can depend on. Oakite ChromiCoat protects for hundreds of hours under the ordeal of salt-spray tests . . . and surpasses MIL-C-5541 specs *several times over!*

And the Oakite process is simplicity itself. No control problem. A thin, golden, uniform coating every time.

ChromiCoat is just one of a line of more than 30 Oakite materials designed especially

for aluminum. There are etch and non-etch cleaners . . . barrel finishing compounds . . . safe paint strippers . . . forming lubricants.

For more information, ask your local Oakite man or write to Oakite Products, Inc., 17 Rector Street, New York 6, N. Y.

it PAYS to ask Oakite



for High Temperature ENGINEERING DESIGNS give Better Service!

The designs illustrated are typical examples of those supplied to our customers every day. Such design studies—specifically **ENGINEERED** for each application—not only help visualize mechanical features of individual jobs, but also illustrate the many alloy design details incorporated for better serviceability.

The unique experience of our staff is reflected in our designs. We of course consider efficient loading, convenient handling, and functional operation with furnace mechanisms. Of equal importance to serviceability is the **ENGINEERING** evaluation of the complex stresses and deformations encountered in use at high temperatures, and in quenching. Atmosphere and quench circulation in critical part areas are given special attention.

An equal caliber of **ENGINEERING** is employed in our product manufacture—where our proprietary processes have received both national and international recognition.



Remember—this unparalleled comprehensive **ENGINEERING** service is available to our customers without charge.

ALLOY ENGINEERING & CASTING CO.
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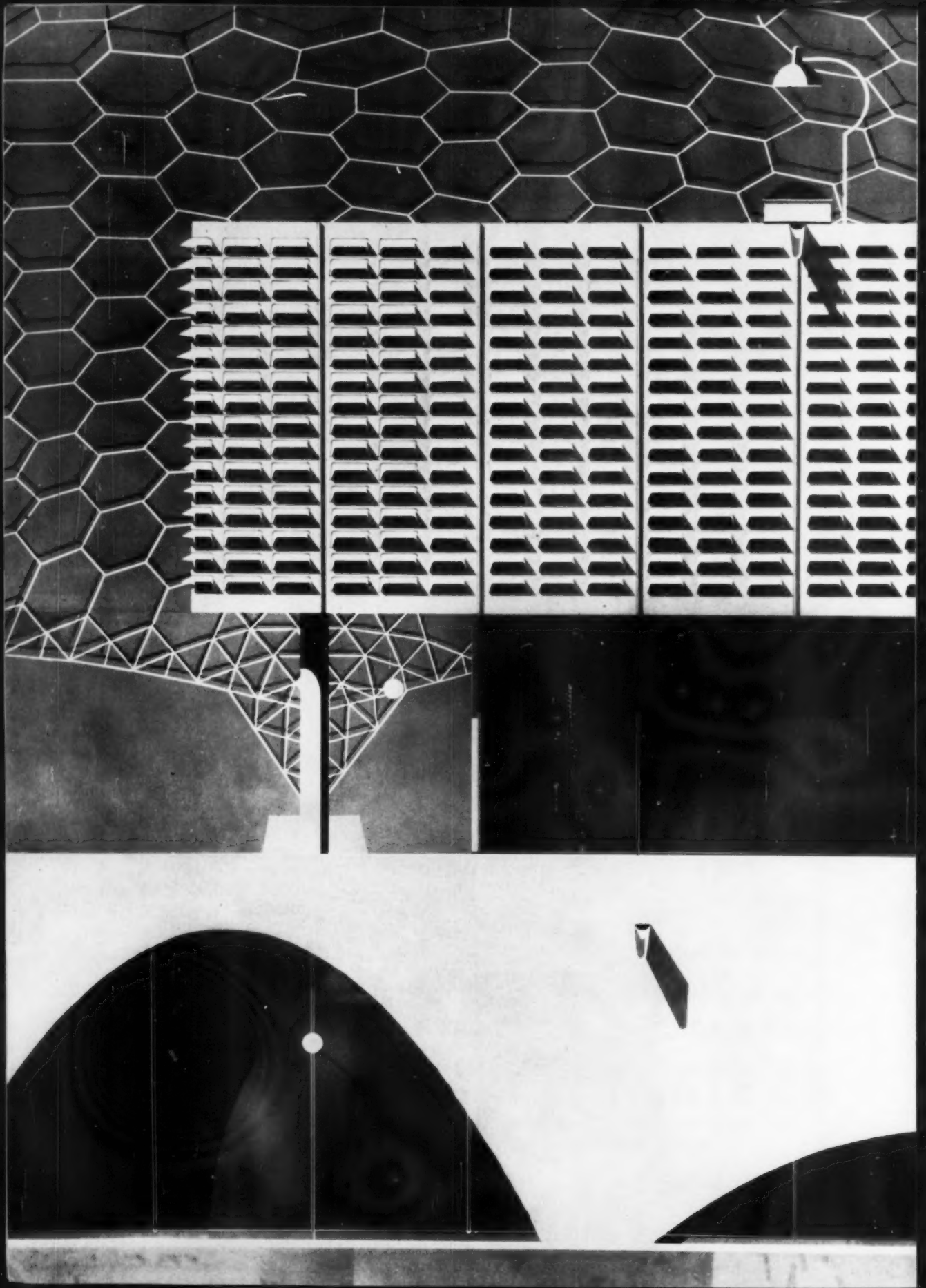
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Moving Day for the American Society for Metals



Construction view shows make-up of double dome and its five pylons. The lower, more highly stressed members are 6-in. aluminum tubes with forged jointures; above, the tubing is 4 in. in diameter, joined by castings. Five miles of tubing and eight miles of 1¼-in. extruded tie rods were required.



WHEN, IN 1940, the American Society for Metals moved into its grand new quarters at 7301 Euclid Ave. in Cleveland, the management and staff felt they were fixed for good. The Society was 20 years old, its membership (recovering from a depression low) had gone up to 11,000 and the staff of 21 people found ample space in the big stone mansion and depended on the large coach house for warehousing and expansion.

Such was not to be. Another 20 years saw such an increase in activities associated with growth of membership to 30,250 and local staff to 105 that five separate buildings were occupied by A.S.M. activities. In fact the Board of Trustees recognized that new centralized headquarters would soon be essential, by making the first appropriation to a building fund in August of 1952. After a study of the comparative advantages of urban and suburban sites, the Board in 1955 decided to go suburban. No less than eight promising sites were examined in detail by a staff committee aided by outside experts in population trends, county planning, real estate and landscape architecture, and finally the Board in May of 1956 accepted the 100 beautiful wooded acres donated by our late National Secretary, Wm. H. Eisenman, a portion of his farm in Russell Township, east of Cleveland. It has been christened "Metals Park".

After about a year of unsuccessful search for an outstanding design, the Cleveland architect John Terence Kelly presented late in 1957 an ultra-modern plan for the building and its setting which was accepted by the Board of Trustees. Construction actually started in April of

1958. Following Mr. Eisenman's untimely death, A. P. Ford, sales manager of *Metal Progress*, was appointed coordinator of the project, which he pursued with such vigor that moving day was Aug. 22, 1959 — so closely on the heels of the builders that the completed building is still surrounded by construction equipment and satisfactory photographs could not be taken to illustrate this story.

As can be seen from the illustrations, the design of the new A.S.M. headquarters combines the utilitarian, the symbolic, and the aesthetic.

The utilitarian part is a three-level office building, a circular arc in plan, extending two-fifths of a circumference.

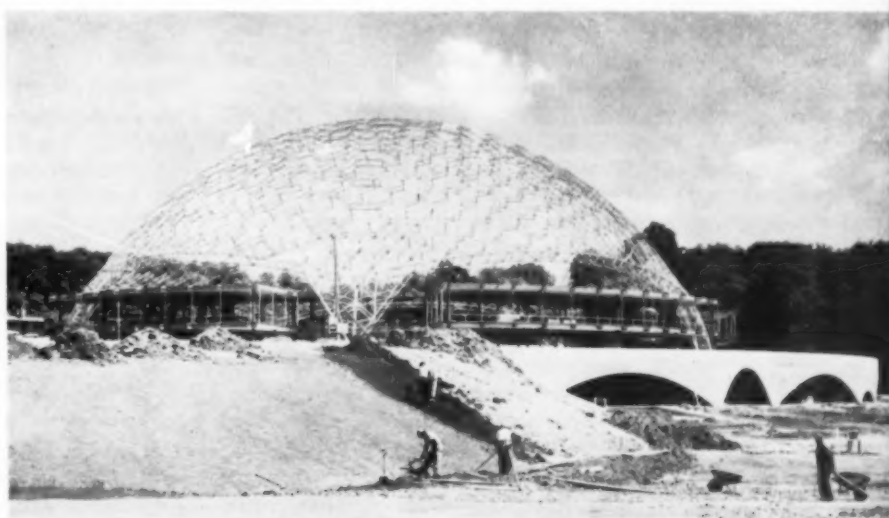
The symbolic element is a hemispherical dome, 250 ft. in diameter, 100 ft. high — an open lattice of aluminum tubing joined into hexagons — a striking symbol of man's mastery over the metals with which he works. The dome rests on five pylons, equally spaced at 72°; two of the five quintants embrace the office building.

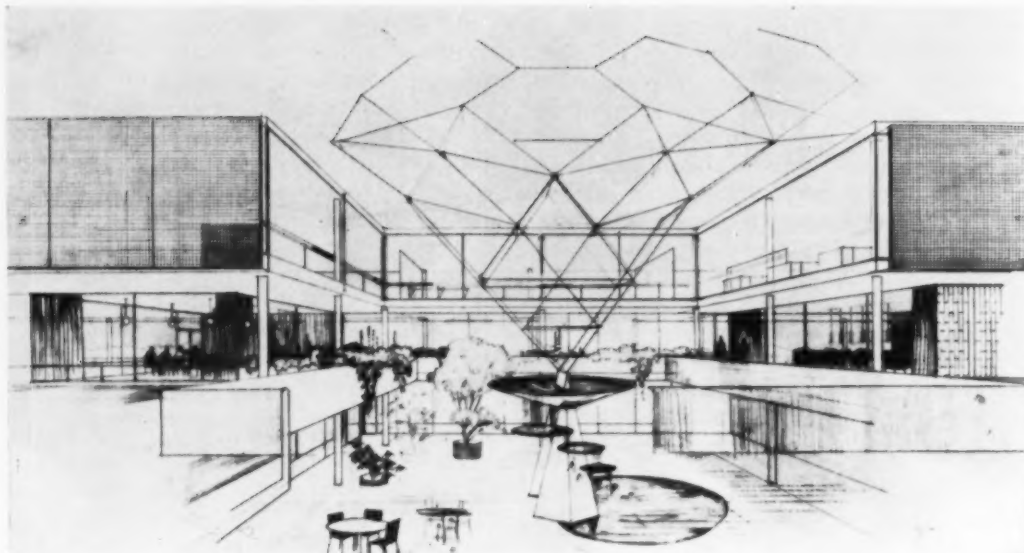
The aesthetic aspect is achieved by building the structure and dome into the rural landscape, so to speak. The dome is open to the sky, the building is glass enclosed and views the surrounding woods and farm land; the rolling countryside merges into a circular piazza and "mineral garden" under the dome where monumental masses of our most important ores will be placed.

Driving into the entrance portico, the visitor will hardly know he is at a building, for he can look through the glass walls of the first floor in almost any direction and see the surrounding landscape. Flanking the entrance lobby on one

Architectural Rendering Visualizes Main Elements of the Monumental New A.S.M. Headquarters. An arched wall leads into the lower level; the other floors are glass enclosed; the top floor has an outside stainless screen on the sunny exposures; crowning it all is the soaring dome, open to the sky

Progress Photograph of Building Nearing Completion, View Looking East. For close-up of what the central portion will eventually look like, see the rendering on the next page





Architect's Sketch of Court in Lower Level. Stainless steel pyramids support space lattice pylon and a series of shallow water basins, fountain-like. On the lower level at this region is the dining room; on the middle level or main floor at left is a conference room and at right is the board room; on the top floor are offices for most of the staff. A stainless steel lattice shields the glass walls from the western sun

side is the library and on the other side an assembly room, the board room and executive offices. The floor above is more commodious, and houses the following main departments, end to end:

- Expositions, in charge of C. L. Wells
- Accounting, in charge of A. A. Hess
- Sales and Advertising, in charge of A. P. Ford
- Metal Progress Editorial, in charge of E. E. Thum
- Metals Handbook, in charge of Taylor Lyman
- Transactions, in charge of T. C. DuMond
- Metallurgical Engineering Institute; in charge of A. deS. Brasunas

The floor below grade contains cafeteria and kitchen, drafting room, membership department, warehouse and heating plant.

A sincere effort has been made to use the modern metals and alloys as extensively as possible in this new national headquarters of the American Society for Metals. In addition to the indispensable structural and reinforcing steel and new enameled steel furniture throughout, stainless steel has been extensively used in a sun shield on the west side and ends of the second floor, in the entrance portico and doors on the first floor, for constructing the main stairway, and in kitchen and cafeteria equipment. Copper, also, is used throughout the heating and electrical system, and brass and bronze on balustrades, elevator and its doors, and innumerable places on interior trim.

In addition to the dome, aluminum finds itself in all window frames. There is titanium furniture in the board room. Undoubtedly as time passes and opportunity presents, many metallic objects of art will further embellish the interior.

Of course all members of the American Society for Metals are most cordially invited to inspect their new building at any time. Being out in the country, it requires an automobile for transportation. If you are in downtown Cleveland, drive to the end of the Van Aken branch of the Shaker Rapid Transit line, thence out Kinsman Road (Route 422) to where Route 87 branches off to the left, thence east on 87 to the site. (You'll see the dome from miles away!)

If you're coming from the East on Route 20, after passing Mentor branch off to the south on Route 306, go as far as its intersection with Route 87 (Russell), thence east to the site.

If you're traveling on the Ohio Turnpike in either direction, leave the pike at Interchange No. 13 at Streetsboro, proceed on Route 43 to its intersection with 306, thence north to Russell and turn east on Route 87 to the site.

We'll be expecting you! The new address is
 American Society for Metals
 Metals Park
 Novelty, Ohio
 Phone: JJordan 4-2271



Critical Points

By the EDITORS

The Dilemma of Materials

IN A SPEECH at the official opening of Republic Steel Corp.'s new Research Center in Cleveland recently, T. Keith Glennan, the nation's space chief, remarked that the first United States nuclear airplane ought to be flying now, considering the vast sums already spent. "We have already spent \$900 million for a nuclear plane," said Dr. Glennan. "If we had put one tenth of this into a sound program for the materials we need, 10 years ago, we would have the airplane flying rather than in development."

Dr. Glennan emphasized that he didn't wish to criticize the spending program but rather to point out that it should teach the nation "a lesson" in spending in the space age. "We tend to get into hardware before we have a full understanding of all the problems," he further commented.

Dr. Glennan's remarks bring to mind comments we recall being made by John T. Norton, professor of metallurgy at Massachusetts Institute of Technology, some two years ago at an A.I.M.E. Conference on High-Temperature Materials. In discussing progress in cermets (or lack of progress!), Dr. Norton stated: "We have concentrated on the problem of making hardware, and as a result we have neither the kind of hardware we want nor the understanding of how to get it. If we now concentrate on the understanding, I believe a superior brand of hardware will be an automatic consequence."

Certainly, these observations re-emphasize the

need for developing more basic knowledge of materials — something we have been hearing more and more about recently. True, much of the accelerated need for discovery and application of new materials can be traced to the insatiable demand of our armed services for new weapons. However, with increasing economic pressure in the metals goods industry, producers of "everyday" products are finding that materials must be tailored more closely to design, manufacture and service requirements. Here, too, basic work has a way of paying off in the long run. Manufacturers are realizing that new devices and improvements in the old ones result from more and more knowledge of the materials with which they work.

There is an important role for the metallurgist in the development of the science of materials because he already appreciates the important relationship between structure and properties so important to an understanding of the fundamental problems of materials engineering. Today's challenge in materials offers the metallurgist an opportunity to expand his interests and to broaden the scope of his activities. In his speech, Dr. Glennan also suggested, "The time has come to change our concept of the metallurgical industries . . . Instead of thinking of the steel industry or the aluminum industry, we should consider them all together as interlocking segments of our dynamic materials industry. Only then can the vast potential of industry in creative technology serve the varied needs of advanced design." Metallurgists of our country could supply the thinking which might start us on the way toward the understanding we must have to work out a solution to our materials dilemma. ☹

Austenitic "Cold Working" for Ultra High Strength

By D. J. SCHMATZ,
J. C. SHYNE
and V. F. ZACKAY*

Need for materials with higher strength-to-weight ratio has motivated the search for new heat treating processes for steels. Key to a technique studied at Ford is plastic deformation in the austenitic "bay" of the TTT-diagram between pearlite and bainite, then quenching to prevent transformation to nonmartensitic products. (J26p, Q27; AY)

A DECADE AGO, martensitic steel of S.A.E. 4340 type, oil quenched and tempered at 900° F. to a tensile strength of about 200,000 psi., was acceptable to the aircraft industry. The high tempering temperature was used to obtain specified elongation and impact toughness. Since then, the development of ultra-high-strength steels has been based on tempering temperatures below the so-called "500° F. embrittlement range", or on modification of composition to permit tempering in the normally avoided 500° F. range. By changes in composition and heat treatment, a series of steels was made which combine good ductility with tensile strengths near 300,000 psi.

A promising hardening technique was suggested by the Dutch scientists E. M. H. Lips and H. Van Zuilen (*Metal Progress*, August 1954, p. 103). They reported unusually high tensile strength for a steel of high hardenability which was heat treated to a metastable austenitic condition, severely deformed between its recrystallization and martensitic transformation temperatures, and then transformed by cooling to room temperature.


Work at the Ford Scientific Laboratory has confirmed the feasibility of improving steel by

this sort of thermal-mechanical processing. A similar technique has been developed by Schmatz and Zackay† called the "Ausform" process‡. It includes austenitizing a steel, quenching it to the austenitic "bay" between pearlite and bainite where it is plastically deformed, then quenching it to room temperature.

In Ausforming we minimize the decomposition of austenite to nonmartensitic products, which may occur in the Lips-Van Zuilen process, by choosing steels with high hardenability, and limiting the temperature range for deformation to the austenitic bay from which the steel is quenched to martensite. Essential features are schematically illustrated in Fig. 1. Microstructure, degree of deformation, and carbon content are significant variables.

The nominal compositions of steels examined were 0.48% C (steel 48) and 0.63% C (steel 63), with 3 Cr, 1.5 Ni, 0.75 Mn, 0.5 Mo and 1.5 Si.

*Scientific Laboratory, Ford Motor Co., Dearborn, Mich.

†"Mechanical Properties of Deformed Metastable Austenitic Ultra-High-Strength Steel", by D. J. Schmatz and V. F. Zackay, *Transactions* , Vol. 51, 1959, p. 476.

‡Registered trademark of Ford Motor Co.

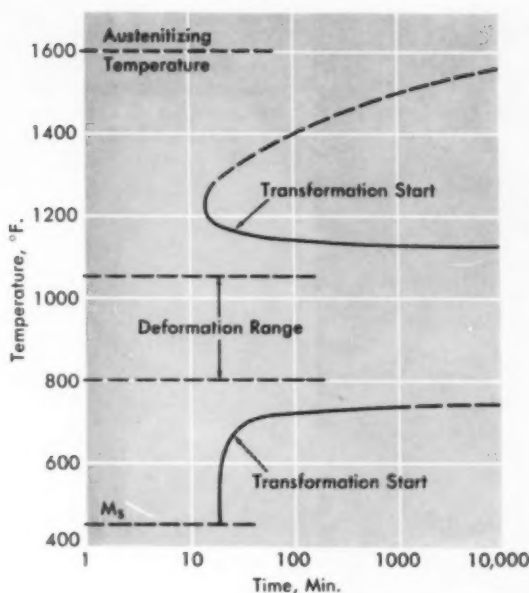


Fig. 1 - TTT-Diagram for Steel Showing Essential Features of Ausforming - Austenitizing and Quenching to the Metastable Austenitic Zone Where the Steel Is Deformed

Present indications are that nonmartensitic transformation products are detrimental. The mechanical properties of steel 63 (deformed 90%) plotted against tempering temperature are shown in Fig. 2. One group of specimens was immediately oil quenched after deformation, while the others were air cooled to permit some nonmartensitic decomposition. The tensile and yield strengths of the steel containing nonmartensitic products were lower than its oil quenched counterpart. Ductility of both steels was found to be comparable.

Differences in microstructure suggest the reason for the superior strength of the oil quenched steel. It was essentially martensitic; however, the air cooled structure of steel 63, shown in Fig. 3, contained extensive nonmartensitic products on slip bands and on twin interfaces. These delineate the extent of metal flow, and their curved and intricate pattern indicates the absence of recrystallization in the severely deformed steels.

Process Refines Microstructure

Steels which have been Ausformed contain a refined microstructure. Electron photomicrographs of a carbon steel are shown in Fig. 4 (no austenitic deformation at left; deformed 93% at right). Both samples were oil quenched and

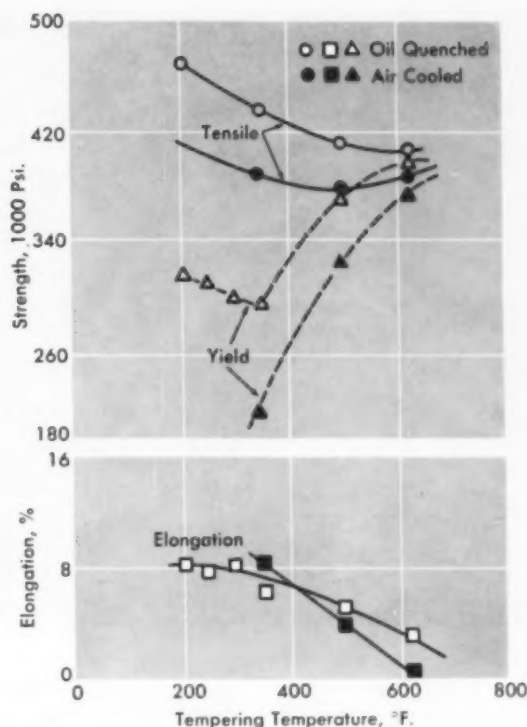


Fig. 2 - Effect of Nonmartensitic Decomposition Products on the Mechanical Properties of Ausformed Steel 63 (3 Cr, 1.5 Ni, 0.75 Mn, 0.5 Mo, 1.5 Si, 0.63 C), 90% Deformed. The air cooled steel contained some ferrite-carbide aggregates; the oil quenched steel was martensitic

tempered at 400° F. for 1 hr. The largest martensite plate shown in the electron micrograph of the deformed steel is 1½ microns long. Martensite plates in the same steel, undeformed, measured about 3½ microns.

A relationship exists between the yield and fracture stresses and the size and distribution of microconstituents in Ausformed steels. The microconstituent size is dependent in turn upon the prior austenite grain size and the degree of deformation.

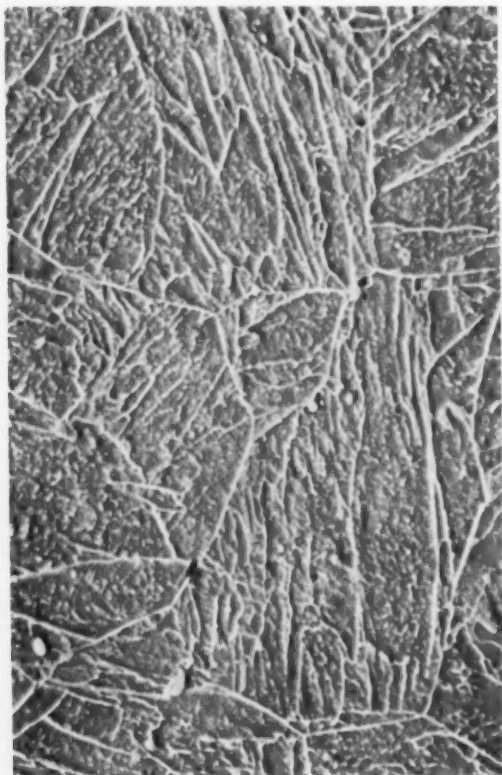
Austenitic Deformation Increases Strength

Preliminary observations show that a critical amount of deformation is required for a significant increase in mechanical properties. Since large amounts of deformation are necessary for significant improvement in properties, and nonmartensitic products should be avoided, both deformation temperature and composition are critical. Optimum properties are obtained only by deforming in the temperature range of an



Fig. 3 — Photomicrograph of Steel 63 (0.63% C) Deformed 90% in the Metastable Austenitic Condition and Air Cooled to Permit Formation of Nonmartensitic Products. 2000 ×

Fig. 4 — Electron Micros of a 0.40% C Steel. Left — Oil quenched from the austenitizing temperature and tempered 1 hr. at 400° F.



Right — Ausformed (93% reduction) and tempered for 1 hr. at 400° F. Deformation has refined the structure. 15,000 ×

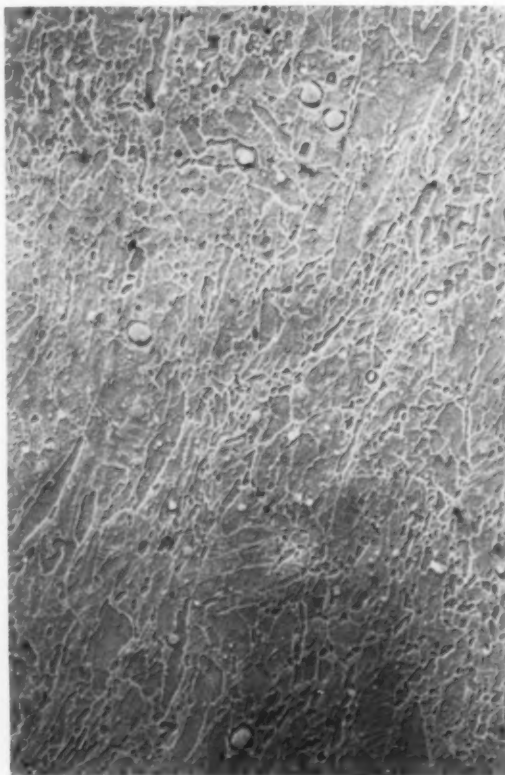
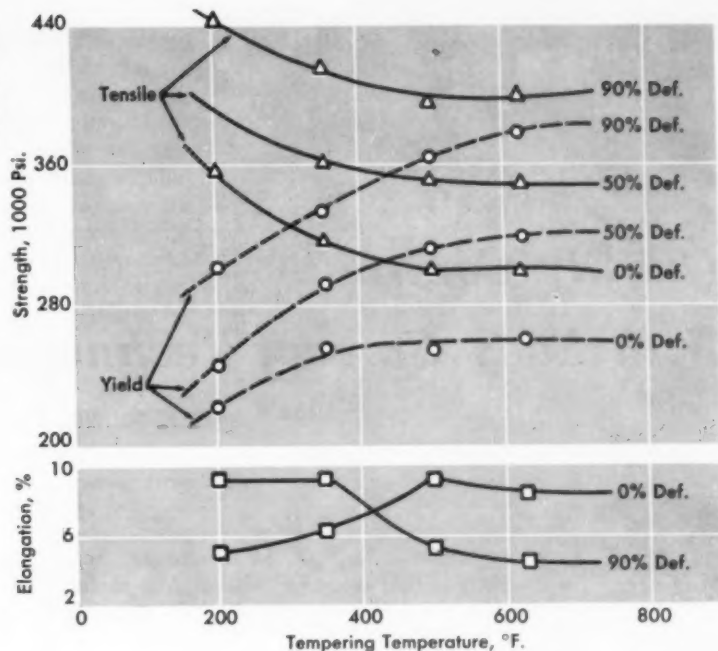


Fig 5—Effect of Austenitic Deformation and Tempering Temperature on Mechanical Properties of Steel 48 (3 Cr, 1.5 Ni, 0.75 Mn, 0.5 Mo, 1.5 Si, 0.48 C)



austenitic bay. The extent of the austenitic bay is determined by the steel composition.

Steel 48 was deformed 0, 50 and 90% and oil quenched. Its yield and tensile strength and elongation are shown as functions of tempering temperature in Fig. 5. Large increases in both the yield and tensile strength occurred after both 50 and 90% reduction. The data for the 0 and 50% deformations were taken from specimens $\frac{1}{4}$ in. in diameter; however, the smaller finished bar of the 90% deformed material necessitated use of a specimen with a reduced section $\frac{1}{8}$ in. in diameter. For this reason, the comparative elongation values should be regarded as qualitative. In general, best ductility was obtained at a low tempering temperature and high rate of deformation.

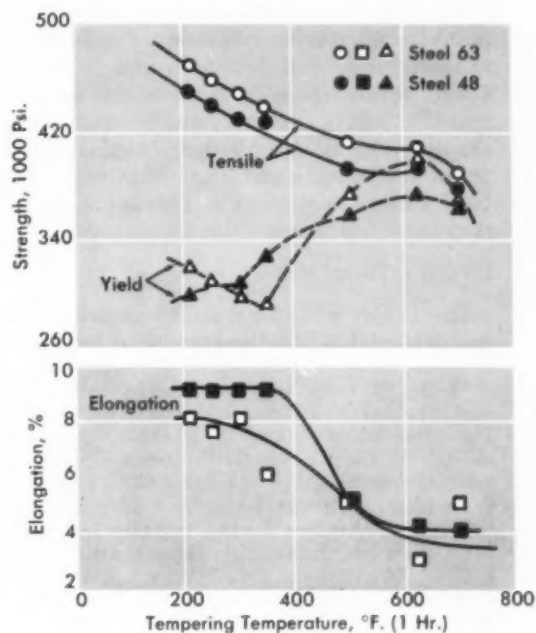
Interstitial Carbon Important

Hardness and strength of martensite are known to be functions of the interstitial carbon content. The effects of carbon on the mechanical properties of steels 48 and 63 deformed 90% are illustrated in Fig. 6. The higher-carbon steel exhibited a greater strength over the complete tempering range. An ultimate tensile strength of 464,000 psi. was observed for this steel after a 212° F. temper. Yield strength rose sharply and uniformly above 350° F. to about 400,000 psi. after tempering at 600° F.

The elongation of steel 48 was generally

greater than that of steel 63. This trend in rising strength and falling ductility with increasing carbon content was similar to that observed in conventionally heat treated martensitic steels. ☺

Fig. 6—Effect of Carbon on Tempered Steels Which Were Deformed 90% While in the Metastable Austenitic Condition



Quality Control

With Eddy Current Techniques

By C. E. QUINN*

A new inspection instrument, the Laminagage, readily measures the thickness of thin gages and plates. Also useful for locating fine cracks, this versatile tester employs plug-in coils and several types of probes. (S13h, S14h, 1-53)

ALTHOUGH EDDY CURRENTS have been used to determine coating gages and surface conditions for only a short time, much of the theory is already known. This knowledge has been applied in designing the Laminagage (Fig. 1), a device which measures thicknesses under 0.010 in. and detects surface cracks and inclusions. Operating through eddy currents, the machine senses differing surface conditions through changes in impedance. Frequencies from 0.1 to 20 megacycles are used. The Laminagage† provides a fast, accurate and inexpensive means for the nondestructive inspection of production parts.

How the Tester Works

The carrier wave at radio frequency is frequency-modulated at the power-line frequency

*Senior Research Engineer, Physics Dept., Research Laboratories, General Motors Corp., Detroit. The author wishes to thank the inventors, R. L. Saur and E. A. Hanyasz, for their cooperation and to acknowledge the aid of J. Felice and C. Glover in this work.

†This tester has been licensed to Gulton Industries, 212 Durham, Metuchen, N.J.; Branson Instruments, Inc., 27 Brown House Rd., Stamford, Conn.; and Photocon Research Products, 421 N. Altadena Dr., Pasadena, Calif.

rate. This modulated signal is coupled to the probe, and the resulting field at the probe coil penetrates the surface being tested. Penetration depth depends on conductivity and permeability of the conductor, power input and proximity of the probe coil, and the operating frequency. When applied to a metallic surface, the probe coil senses a change in impedance because there are current losses in the conductor. This change is also reflected into the driving oscillator which produces a signal pulse relative to the start of each sweep cycle. After pulse amplification, additional circuitry provides an average current which is indicated on a meter. When energy flux of the proper frequency penetrates into the conductor, and the power input and spacing of the work coil are held constant, variations in the conductor thickness will change the average current and corresponding meter reading. Through appropriate standards, the meter may be calibrated in thickness.

Measuring Thicknesses

An overlay, according to our definition, consists of a thin coating on a base metal of considerably greater thickness. If the coating conducts, it must have a different conductivity or permeabil-

ity (or both) from the base metal. Frequency, coil spacing, and power input must also be adjusted so the field can penetrate the top coating and enter the base. However, if the coating is nonconductive, significant penetration into the base is not required. In fact, it is often undesirable since less penetration of the base provides increased sensitivity to thickness variations. In both instances, surface roughness affects the thickness reading because the induced eddy currents are distorted. Although bothersome for thickness measurement, this provides a very efficient method for crack detection, as will be discussed later.

Conducting overlays must be measured empirically to find the optimum frequency and coil spacing which can best isolate the coating from the base. A typical fixture for a probe coil used to measure copper plating is shown in Fig. 2. Base material was cold rolled steel tubing; copper plate was 0.0003 to 0.0006 in.

A problem recently solved with the lower frequencies is measuring the thickness of copper on zinc. Copper thickness varied from about 0.0005 to 0.002 in. Conductivities and permeabilities of this combination are very close, but a frequency of 200 kc. per sec. can measure the copper successfully.

Nonconducting overlays on cold rolled steel can usually be measured successfully with the Laminagage. The tester gives very satisfactory results on nonconductors such as paint, plastic, and porcelainized coatings up to 0.0075 in. An area of the bare metal must be accessible to establish a base reference. Calibration for nonconductors can easily be made by using thin Mylar or other insulator of known thickness between the probe and the base metal. A good rule of thumb is to employ the lowest frequency possible, taking base metal, coating thickness and sensitivity into consideration. This helps to lessen the effects of slight material curvatures and chemical variations. However, if too low a frequency is employed on thin base materials (0.001 to 0.02 in.), the overlay reading may be in error due to sensitivity to the thickness of the base. If the base material gives nonuniform readings at high frequencies, sensitivity must be sacrificed in favor of a lower frequency.

In general, very thin layers are measured at frequencies higher than 600 kc. per sec. For example, an anodized coating on aluminum usually varies from 0.0001 to 0.005 in. A frequency of 10 to 20 megacycles per sec. is required for this measurement.

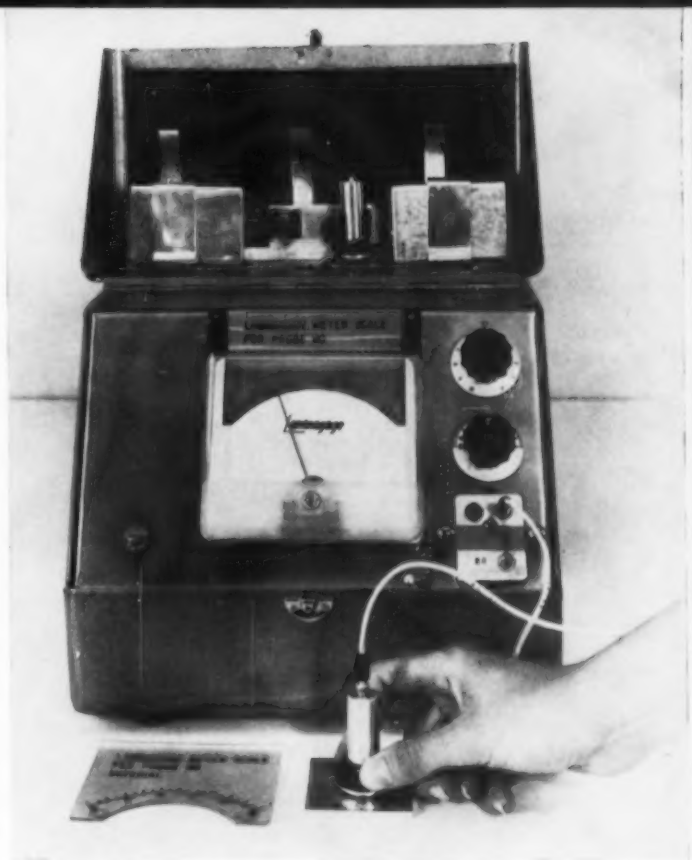


Fig. 1 — Using the Tester for Measuring Thickness of Flat Surfaces. Plug-in coils range from 0.1 to 20 megacycles per sec.; this instrument can thus be easily adapted to inspect a wide variety of plates and base metals

Thin metal foils, ranging from 0.001 to 0.010 in., can also be measured. This may be done by flattening magnetic foils on a nonmetallic base, or nonmagnetic foils on a steel base. (In the latter instance, sensitivity is greatly increased.) Frequencies between 0.3 and 2 megacycles per sec. are used depending on the thickness range and accuracy desired.

Magnetic materials, with their higher permeability and lower conductivity, offer much higher sensitivity to eddy current inspection. However, their wider chemical and conductivity variations (and residual magnetism) may mask overlay thickness indications.

Measuring Multiplates

As stated above, the thickness of a conducting overlay on a base metal may be measured providing there is sufficient difference between conductivities or permeabilities or both. In measuring multiple thicknesses, this factor is used to isolate the top and second coatings from the base metal. Such an application is the meas-



Fig. 2 — Special Clamp Holds Coil in Position While Measuring Copper Plating on Steel Tubing. Other probes and coils can be selected to measure multiple coatings and detect surface defects

urement of nickel over copper on a zinc base. The nickel, which is measured first at 600 kc., affects the copper measurement. Copper and zinc, being close in conductivity and permeability, look the same to the probe at 600 kc. per sec. Consequently, the hidden copper is measured at a lower frequency, 200 kc. per sec.

Measurements of this type require accurate foil standards for basic calibration. Tests to date indicate that all triple plate combinations will not lend themselves to this procedure. For instance, in a plating buildup of cold rolled steel covered with copper and then nickel, a frequency low enough to measure the nickel thickness will also penetrate the copper and enter the steel base. This means that the probe will recognize copper or nickel thickness variations, and readings will be in error.

Detecting Surface Cracks

Since its inception, the Laminagage has been recognized as an excellent locator of surface cracks. Fine defects, visible only with a 50-power microscope, may be easily detected. The use of radio frequencies and a probe coil with a small diameter greatly increases the sensitivity

to small cracks but necessitates mechanical scanning of the surface. When the probe passes over a crack, the induced flux is distorted, causing a change in coil impedance which is sensed by the Laminagage circuit. This change can be indicated on a meter, or it may furnish an output pulse to trigger sorting equipment.

Any metal surface, from rough castings to machined parts, may be scanned in this manner. Frequencies from 600 kc. per sec. (for coarse-grained castings) to 20 megacycles per sec. (for machined parts with fine grain) are used. Successful use of the higher frequencies depends on surface uniformity as well as other items such as chemistry, residual magnetism, grain size and hardness. Scanning rate depends on the surface condition and type of indication desired. Figure 3 shows the meter indication method for inspecting spark plug shells at a slow speed. For scanning (ranging from 4 to 12 in. per sec. as required on automated lines), electronic circuits provide automatic sorting.

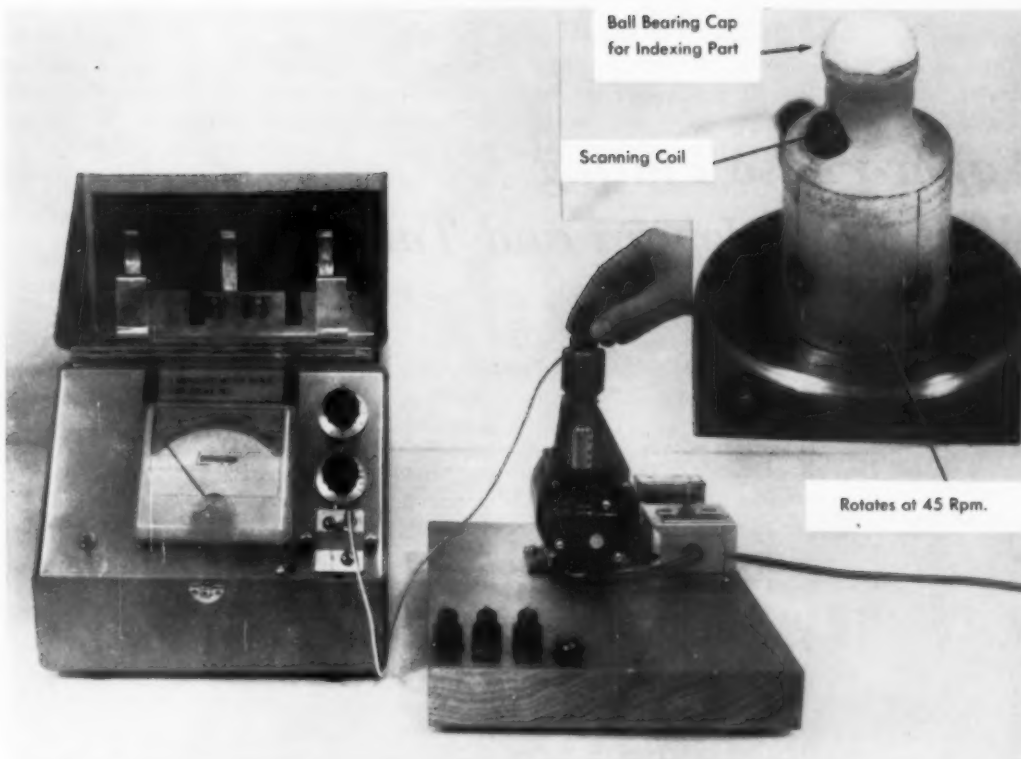


Fig. 3—Scanning the I.D. of an Extruded Shell. Inset shows spring-biased scanning coil on sapphire rod mounted in 45-rpm. fixture

For successful work, the probe must be correctly designed. A hand-held probe should, of course, be easy to handle; it must also provide accurate, reproducible readings. The probe in Fig. 1 was designed with this in mind. The one-piece handle and foot section has three nylon ball feet which sit on an area less than $\frac{3}{4} \times \frac{3}{4}$ in. Spring loaded, the coil insert keeps the adjustable sapphire touching the test sample. The coil is pancake-wound of either wire or tape to suit the sensitivity requirement. Adjustment of the sapphire provides control of sensitivity and minimizes effects of slight curvatures.

Some applications—crack detection, for example—do not require spring-loaded probes. When inspecting for cracks in rough castings, a probe having a teflon bearing surface and a slightly recessed coil to prevent winding damage has been successful. In scanning rotating parts for crack detection, curved pancake coils or small multilayer solenoids are used. They can be spring loaded or fixed depending on the concentricity of the part.

To sum up, eddy-current testing at high frequencies has many advantages and disadvantages. The method is useful on almost all metals and nonconducting overlays, and can measure coating thickness to a ten-thousandth of an inch. It is responsive to surface conditions, and penetration can be controlled to improve sensitivity. In fact the probe does not always need to touch the work. Since the method can be used on either inside or outside diameters of tubes and requires no special training, it is useful in mass-production applications.

There are some drawbacks, of course. Sensitivity of the method, though helpful in many respects, makes adjustment quite difficult. The probe coil must be aligned precisely, and the instrument is sensitive to variations in chemistry, stress, and hardness. Due to the method's low depth of penetration, special probes are required for specific areas and the test area must have the same contour as the standards for calibration.

Despite these problems, the Laminagage has proven to be a most useful instrument. Its wide frequency range and plug-in circuitry make it extremely flexible for measuring overlays and detecting cracks.

Vapor-Phase Plating With Molybdenum and Tungsten

By H. W. SCHULTZE*

Deposits of metals or their refractory compounds are produced from chlorides and carbonyls of molybdenum and tungsten at temperatures considerably below the melting point of the metals. Coatings can be produced on a variety of metals: ceramics, glass, refractories and graphite. Interest in the process is spurred by today's technological needs and commercial availability of the plating chemicals. (L25; Mo, W)

INTEREST TODAY in vapor-phase deposition of molybdenum and tungsten is growing — and for good reason. Where fabrication from massive metal is difficult and not economical, this new technique may hold the answer. Even more important for missile and space applications is the weight saving possible by applying coatings of these metals on low-density refractories or graphite. The technology of vapor-phase deposition has advanced to the point where industry can now evaluate its application to specific problems. Enough is known about the process variables, characteristics of deposits, and the nature of required base materials to recognize areas of potential application.

The use of vapor-phase deposition may sometimes be necessary because there is no alternative. For example, there is no successful method for the electrodeposition of pure molybdenum or tungsten. In other instances, vapor plating gives a composite part which may offer advantages not obtainable with either material

alone. The processes also yield pure molybdenum and tungsten metals without going through oxide phases.

Scope of Process

Vapor-phase deposition results from the chemical reaction of a gaseous molybdenum or tungsten compound at a heated surface. The process is reasonably versatile, permitting the deposition of the metals or their refractory compounds (borides, nitrides, carbides, silicides) on outer and inner surfaces and irregular surfaces, generally without weakening the base material.

Both conductive and nonconductive materials can be coated without liquid or gaseous entrapment. Thickness of coatings can be controlled and deposits are adherent, stable, and for the metal coatings, ductile.†

Molybdenum and tungsten have been successfully deposited on copper, nickel, cobalt, rho-

†Outstanding contributions to an understanding of carbonyl decomposition were made by Lander and Germer of Bell Laboratories, and of hydrogen reduction of molybdenum pentachloride by Wulff and co-workers at Massachusetts Institute of Technology. The commercial aspects of carbonyl

*Manager, New Chemical and Catalyst Development, Climax Molybdenum Co., division of American Metal Climax, Inc., New York.

dium, alloy steels, iron, graphite, porcelain, alumina, fused silica, silicon carbide, uranium dioxide, Pyrex glass, glass fibers, sintered carbide, Inconel and molybdenum screening, and tile. This variety of base materials (and no doubt there are others) presents many product possibilities.

Applications for Vapor Plating

Some items on which molybdenum and tungsten might be vapor deposited are rocket nozzles, combustion chamber linings, X-ray tube targets, die blocks and cores, crucibles, gas turbine blades, valve and cylinder linings, small thermocouple wells, resistance thermometers, bolometers, and transistors. For certain corrosion resistance uses, it may be desirable to deposit

molybdenum or tungsten may prove useful as catalysts for chemical processing. Compacting such particles may also produce cermets with greater strength, improved heat transfer and better thermal and mechanical shock resistance.

Electronic Applications

An interesting application study was made by Bell Laboratories on continuous coating of copper magnetron rings, 0.8 cm. I.D. Purpose of the 0.0002-in. molybdenum coating was to dissipate the heat generated by electron bombardment and to provide strength at high temperatures. The initial bond to the copper was made at 800° C. (1475° F.) and plating was continued at 650° C. (1200° F) in wet hydrogen. The hard-

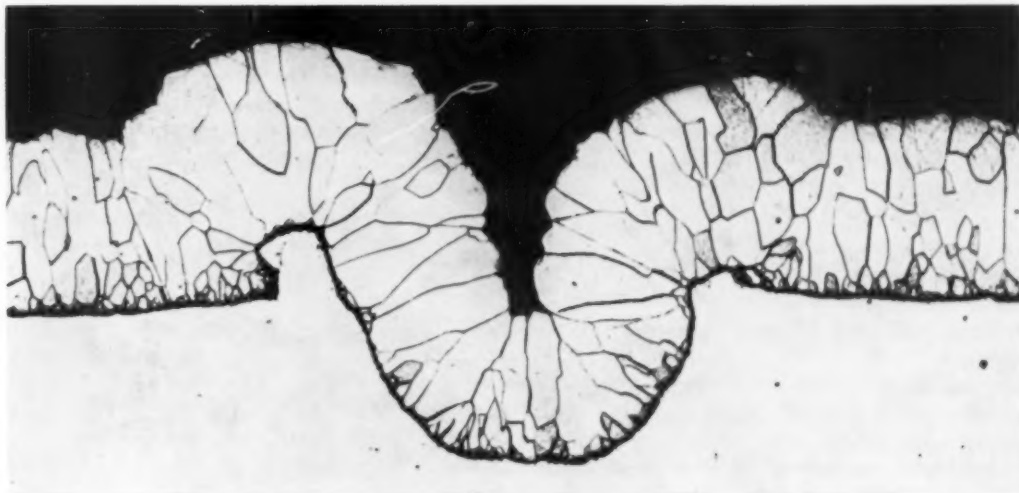


Fig. 1 — Molybdenum Metal Vapor Deposited on Inconel. Note how the deposit follows the surface contour. 125×. (Courtesy Massachusetts Institute of Technology)

molybdenum and tungsten on chemical ware and piping. Molybdenum's good nuclear properties may make it useful for cladding reactor components.

Techniques have been devised for continuous coating of wire, rod, strip, and tubing with high-purity molybdenum and tungsten. A molybdenum coating, 0.0005 to 0.0009 in. thick, can be deposited on copper wire at a rate of 0.0001 to 0.0002 in. per min. in lengths up to 1000 ft. The coating is ductile enough for spooling the wire.

Refractory and ceramic particles coated with decomposition have been studied by Commonwealth Engineering Co. and hydrogen reduction by National Research Corp. Contributions to knowledge of both processes have been made by Battelle Memorial Institute. Work is still being carried on by these groups and by a newcomer, Alloy Research Corp.

ness of the deposited molybdenum was Vickers 220. This coating was deposited in 4 min.

Molybdenum and tungsten deposits containing carbon and carbides possess wear properties which might make them well suited for bearings, dies, rolls, gages, and a variety of tools. Modified surfaces containing molybdenum disulphide may be useful for semiconductors or lubricants. Electrical contacts can be coated with tungsten carbide to prevent arcing. Electrodes or grids coated with molybdenum carbide improve heat resistance and are poor electron emitters. It is quite possible that equipment could be built to continuously coat such small electronic and elec-

trical components. Ultra-high-purity molybdenum metal is being made by hydrogen reduction of the chloride and equipment is being built to make metallic tungsten this way.

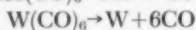
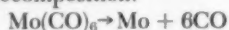
Co-Deposition of Alloys

An intriguing possibility is the simultaneous reduction of the plating gases to produce alloys. Alloys containing up to 18 to 19% W in molybdenum have been reported. Actually these deposits may not be true alloys, but rather intimate mixtures of molybdenum and tungsten which may have unique properties. Addition of other metals to molybdenum in even small quantities by simultaneous vapor-phase deposition may widen applications for this metal.

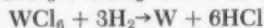
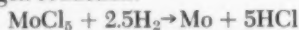
Processes for Vapor Plating

Two processes are available — thermal decomposition or pyrolysis of the volatile carbonyl and hydrogen reduction of the volatile chloride.

Thermal decomposition:



Hydrogen reduction:



Choice of process depends on the material to be coated, temperature which can be used, plating rate required, and properties desired in the deposit.

Metals are plated from these gases with high throwing power (Fig. 1). In plating tubes with molybdenum, which were made of woven or wrapped wire mesh, workers at Massachusetts Institute of Technology found that all the pores were filled. Wire mesh of copper, Nichrome, and molybdenum has been coated in this manner. With molybdenum wire mesh, it was necessary

to preplate the molybdenum for satisfactory adhesion.

Properties of Plate Vary

Control of conditions for deposition determines the properties of the plate. The temperature of the part being coated is one of the most critical variables, followed closely by the pressure of the plating gas. Fine, crystalline deposits which tend to be hard and brittle are obtained at low temperatures. Higher temperatures give coarse, crystalline deposits which are soft and ductile. When temperatures are too high, powdery, nonadherent (frequently pyrophoric) deposits result due to premature reactions away from the surface. A uniform temperature on the part to be coated prevents deposit buildup at "hot spots".

Parts may be heated by internal resistance, high-frequency induction or external means. A moving induction coil is the best way to coat long specimens to prevent uneven or "flow" buildups. Wire-wound external heating with shunts is a convenient alternative in spite of lower efficiency because the chamber is coated as well as the specimen. The direction in which the heated zone moves is important. It should move toward the gas supply so that only exhausted gases pass over the deposited metal.

The best metallic deposits are obtained at pressures less than 20 mm. Hg, although good deposits have been reported at pressures up to and above atmospheric pressure. Often, high pressure and high concentration of plating gas give powdery, nonadherent deposits. Considering the low concentration of plating gas, it is advisable to use inert carrier gases, such as helium or argon, to assure adequate flow through the reaction chamber. In some instances, hydro-

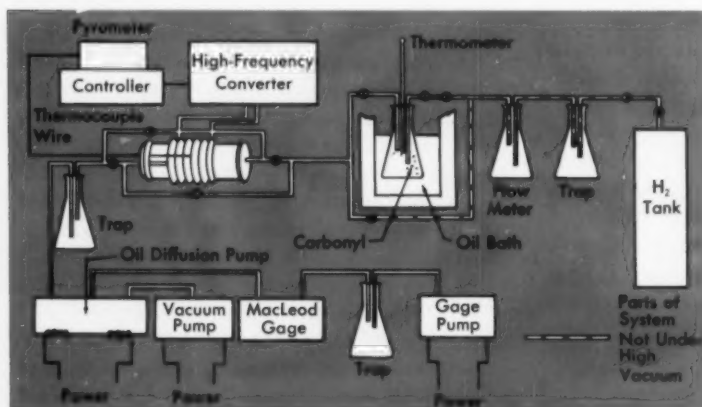


Fig. 2—Equipment Designed by Sam Tour & Co. for Vapor Deposition of Molybdenum From the Carbonyl

gen alone may be an adequate carrier (as well as reactant gas in hydrogen reduction).

Adhesion Is Important Factor

Good adhesion or bonding of the deposit to the base metal is important, because this, to a large extent, determines the utility of coated parts. Three types of bonding may occur: diffusion, penetration, or mechanical. Temperatures must be high enough to cause diffusion of the coating into the base metal where this type of bond is needed. Slight irregularities in the surface actually promote "locking in" of the deposit because the metal follows the surface contours, as seen in Fig. 1.

Pretreatment of Base Metal

Cleaning is important and preplating is frequently used to assure good adhesion of the deposit. Hydrogen, reacting with surface oxides, will form water vapor which cannot diffuse

through the deposit—and blistering results. Sand-blasting, while adequate for some parts, may entrap fine particles in the surface and thus prevent adhesion during deposition.

When depositing on carbon steels and irons, flash coatings of at least 0.001 in. of copper, cobalt or nickel can be applied beforehand to prevent formation of brittle carbides and brittle iron-molybdenum intermetallic layers. These preplates will prevent blistering which otherwise might be caused by the release of gases from the base metal at the high temperatures and low pressures used. A vacuum pretreatment also may be used here.

Equipment and Economics

All equipment for vapor plating must be constructed to avoid leakage of air or contamination by carbon from seals or gaskets. Deposition systems may range from simple equipment, such as shown in Fig. 2, to the highly instrumented

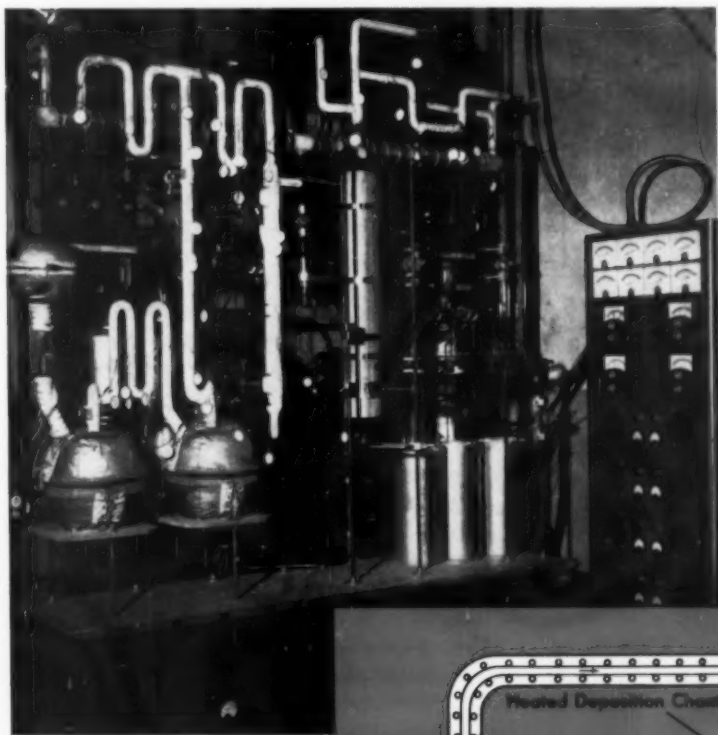
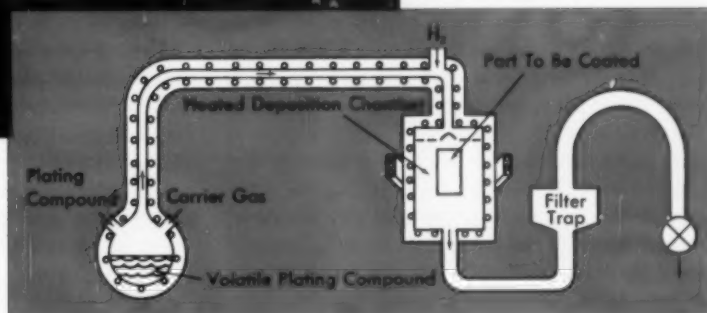


Fig. 3—This All-Glass System, Highly Instrumented, Was Designed by Alloyd Research Corp. for Plating Molybdenum and Tungsten by Hydrogen Reduction of Chlorides. Drawing (inset) illustrates flow of gases



all-glass systems in Fig. 3. Figure 4 shows an all-metal system, constructed from everyday engineering materials. The relative costs of coatings can be compared on the basis of approximate cost of the raw materials required to give a coating 0.001 in. thick on 1 sq.ft. of surface, as follows:

CHEMICAL	COST
MoCl ₅	\$ 0.53
Mo(CO) ₆	2.55
WCl ₆	1.99
W(CO) ₆	18.05

The costs, particularly of tungsten carbonyl, are expected to decrease as volume uses develop.

the gas mixing system at temperatures around 350° C. (660° F.) prevents the chloride from condensing without hydrogen reduction. The melting and boiling points of the two chlorides are:

	MoCl ₅	WCl ₆
Melting point	194° C. (380° F.)	275° C. (530° F.)
Boiling point	268° C. (510° F.)	347° C. (660° F.)

Deposits ranging from a few hundredths of a mil to 0.25 in. or more thick can be made by hydrogen reduction of the chlorides. These deposits are dense and uniform and have well-defined columnar grain structures which are apparently impervious.

Most of the research on hydrogen reduction has been done on small equipment, with reaction chambers up to 2 in. diameter and up to 40 in. long. Based on experiments, the optimum conditions for vapor-depositing molybdenum and tungsten are:

Pressure — Less than 20 mm. Hg.

Temperature of part — 800 to 1100° C. (1475

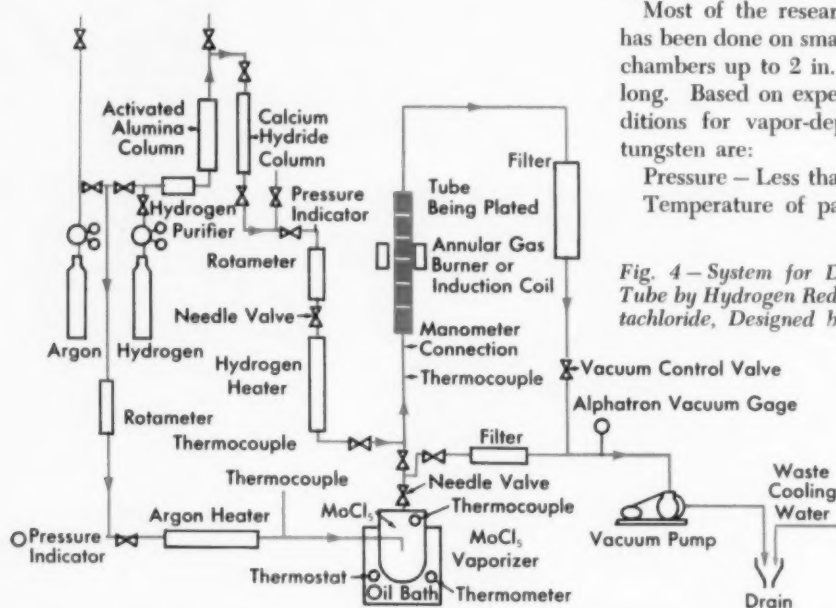


Fig. 4 — System for Depositing Molybdenum on Tube by Hydrogen Reduction of Molybdenum Pentachloride, Designed by National Research Corp.

Molybdenum pentachloride and tungsten hexachloride are now commercially available in such purity that a minimum of prepurification is required. The plating system illustrated by Fig. 4 is typical of what is used. The best molybdenum deposits have been obtained with a ratio of hydrogen to molybdenum pentachloride of at least 10 to 1, total pressure of 20 mm. Hg and temperatures ranging from 800 to 1100° C. (1475 to 2000° F.).

Adequate gas flow is assured by mixing the hydrogen-molybdenum pentachloride gases with an inert carrier gas. The carrier gas is either bubbled through the molten chloride or passed over its surface until saturated, then mixed with the proper volume of hydrogen. Maintaining

to 2000° F.) for MoCl₅; 1000 to 1500° C. (1830 to 2730° F.) for WCl₆.

Temperature of vaporization of metal halide — 130 to 150° C. (265 to 300° F.) for MoCl₅; 165 to 230° C. (330 to 445° F.) for WCl₆.

Ratio of H₂ to halide gas — no less than 10:1.

The effect of temperature can be seen by a comparison of plating rates of molybdenum from the pentachloride at 5 mm. Hg. At 800° C. (1475° F.) plating rate is 0.005 in. per hr., while at 900° C. (1650° F.) it is 0.020 in. per hr.

Ceramic particles such as silica, uranium dioxide, silicon carbide, and alumina have been coated with molybdenum and tungsten. In coating these particles it is important to keep them fluidized so they may be plated uniformly. This

can be done either by gas flow or mechanical agitation. Metal-coated particles of this type can be useful for making high-temperature metal-ceramic bodies.

Carbonyl Decomposition or Pyrolysis

Molybdenum and tungsten hexacarbonyl are stable compounds which volatilize at low temperatures. At temperatures above 150° C. (300° F.), they decompose thermally, producing metal and carbon monoxide. In contrast to carbonyls of the first transition series, which are toxic and difficult to handle, molybdenum and tungsten hexacarbonyls are solids at room temperature and, according to Sax*, are relatively safe to handle.

Control of the process variables is perhaps more important in carbonyl decomposition than in hydrogen reduction. As in hydrogen reduction, control of temperature of the part and pressure of gas appears to be most critical. Low temperatures produce fine crystalline, generally hard deposits while high temperatures yield coarse crystalline deposits that tend to be soft and ductile. Due to the low decomposition temperature of carbonyls, premature decomposition may be caused by heat radiating from the specimen if its temperature is too high. This is a serious problem when long pieces are coated internally. Deposits obtained under such conditions are powdery and nonadherent.

Duplex Methods

Where diffusion produces good bonds between the base and the deposit, high specimen temperature should be used. The "duplex" method developed by Sam Tour & Co. for plating titanium can be used to offset the problems associated with high temperatures such as powdery deposits and changes in the microstructure of the base metal. Diffusion is assured by brief deposition at a high temperature. The temperature is then reduced to a point which permits useful deposits to be made and will not alter the microstructure of the material being coated.

Although it is reported that the metals can be deposited at atmospheric pressure in an inert atmosphere, the best deposits are obtained at pressures of 0.01 to 20 mm. Hg. Compared to the hydrogen reduction method at the same pressure, carbonyl decomposition is slower. But it can produce satisfactory deposits at lower temperatures. Plating rates of 0.0022 in. per hr.

*Dangerous Properties of Industrial Materials, by N. Irving Sax, Reinhold, New York, 1957.

have been reported for molybdenum. Tungsten may be plated faster because it is less susceptible to carbon contamination at high pressures.

Wear Resistant Coatings

The carbonyl process permits the deposition of carbide surfaces or carbon-containing deposits having excellent wear resistance. Carbon content can be controlled from 0 to 35 at.% — hence hardness or wear resistance can be controlled. When the plating gas is made up of carbonyl alone, deposits contain large amounts of metal carbide. Mixing hydrogen with the plating gas decreases the carbide content but increases the carbon content (it also serves as a carrier gas). By adding water vapor to the carbonyl and hydrogen, however, carbon formation can be decreased, as shown for molybdenum coatings:

PLATING TEMPERATURE	H ₂ O IN PLATING GAS	VICKERS HARDNESS
500° C. (930° F.)	0%	1030
	2	1000
	8	800
550° C. (1020° F.)	0	920
	2	740
	8	430

Parts in the above tests were prepared under identical conditions — H₂ pressure equaled 0.12 mm. Hg and CO 0.08 mm. Hg. Annealing these parts reduces the hardness of the coatings in some instances to as low as Vickers 200.

Control of the partial pressures of gases in the plating gas mixture is important for a useful deposit. The following partial pressures are reported to give the best metallic deposits: Mo(CO)₆, 0.02 mm.; W(CO)₆, 0.10 mm.; water vapor, 0.20 mm.; hydrogen, 2.0 mm. Temperatures used should be in the range 350 to 600° C. (660 to 1110° F.).

Tungsten deposits are generally harder and may be more difficult to produce because the carbonyl is more easily reduced. But tungsten is less likely to form carbides or powdery deposits at higher temperatures and pressures. A "pack" technique has been developed by National Research Corp. The piece to be coated is packed in a mass of finely divided metal carbonyl powder and is heated by resistance. Recommended temperatures for optimum plating are: Mo, 160° C. (320° F.); W, 170° C. (340° F.). Deposits up to 0.00004 in. are obtained. By introducing hydrocarbons, hydrogen sulphide, or boron-containing gases into the plating gas mixture, a variety of modified surfaces are obtained. These contain metal carbide, sulphide, or boride.



Fig. 5 — Threaded Copper Tube Which Has Been Vapor Plated With Molybdenum. Large surface discontinuities tend to produce a fine-grained equiaxed structure. 75 ×

Properties of Deposited Metals

Thermal and electrical properties of vapor-deposited molybdenum and tungsten are affected by the density of the deposit. Inclusion of carbon or carbides may alter these properties significantly. Vacuum-tight seamless tubes of tungsten, 0.04 in. thick, have been deposited from tungsten hexachloride at 2000° C. (3630° F.) on a molybdenum tube ¼ in. diameter by 14 in. long. Similar vacuum-tight deposits of tungsten

have also been made on copper at lower temperatures.

Hardness of deposited coatings ranges from Vickers 50, for single-crystal tungsten prepared by chloride reduction, to Vickers 2000 for hard tungsten coatings containing carbon. Molybdenum deposits with Vickers hardness of 170 to 1560 have been obtained by hydrogen reduction of the pentachloride; here, hardness values of 230 to 350 are most common. Alloyd Research Corp., by using highly purified raw materials, expects to produce ultrapure deposits of molybdenum and tungsten which are considerably softer than those produced up to now.

The columnar grain structure of molybdenum deposited from the chloride is well defined. Although its lateral strength is relatively poor, this may be overcome by working. Large surface discontinuities, such as threading (Fig. 5), tend to produce more equiaxed and fine-grained deposits. Molybdenum and tungsten coatings deposited from carbonyls are harder and more brittle than those produced by hydrogen reduction. This may be due to carbon entrapment during decomposition. Annealing the coating will soften it, but this may weaken its bond to some metals.

Excellent bonds have been obtained in a number of applications. For example, a ½-in. long, hardened steel specimen was coated with a 5-mil thick molybdenum layer. After subjection to a 20% compression, parallel to the surface, the deposit showed no signs of cracking or spalling. Even with additional compression, at least part of the failure occurred in the plate, and no spalling was observed. Average shear strength was 100,000 psi. parallel to the bond, but only 25,000 psi. normal to the bond. This is attributed to the columnar crystals.

Fig. 6 — Grains of Molybdenum Vapor Plated on Copper Have the Same Crystal Lattice Orientation as the Basis Metal. 125 ×. (Courtesy Climax Molybdenum Co.)



Mechanical Testing With a 3000° F. Radiant Heat Furnace

*By J. K. HOY**

A radiant heat furnace which operates up to 3000° F. is powered by quartz pencil lamps. Predetermined test temperatures with programmed heating cycles are readily obtained and accurately stabilized with an automatic control recording system. The test chamber is simple to operate and can be adapted to many uses. (X24f, Q27, 2-62)

JETS AND MISSILES flying at speeds of mach 4 and upward generate skin temperatures and conditions that challenge the best of the heat resistant materials. Consequently, before such materials are used in engines or airframes, they must be tested thoroughly. Testing in actual flight, of course, is virtually out of the question. However, designers must have unchallengeable data to select the proper materials. We must, therefore, do our best to simulate time, temperature and stress conditions in the laboratory.

The radiant heat system discussed here was designed for this purpose. Such items as specimen shape, heating requirements, ease of loading, and strain measuring equipment all had to be considered. We wanted the temperature range to be as broad as possible; furthermore, 3000° F. must be reached and stabilized within 3 min. or less. In addition, the test chamber should use any atmosphere: air, vacuum, partial pressure, pressure or inert. This chamber also had to be large enough to hold stress-strain apparatus, provide easy access for loading and unloading, and be capable of performing various heating and cooling cycles. Furthermore, temperatures across the gage section of a tensile test had to be as uniform as possible.

Deficiencies of Conventional Equipment

Conventional heating methods and equipment do not meet these requirements. Furnaces with

the standard Nichrome or Kanthal elements cannot reach this temperature range, nor will they heat as rapidly as desired. Molybdenum, tantalum or tungsten furnaces, though capable of rapid heating and high temperatures, are restricted to vacuum, inert or reducing atmospheres. Graphite elements can reach still higher temperatures but they produce carbon monoxide when operated in air; this may or may not be desirable. Also, the large masses of graphite needed will act to reduce heating and cooling rates.

High-frequency heating introduces molecular and atomic motions within the test material; their effect may complicate results. If the test specimen is heated by its own resistance, the problem of uniform temperatures across the gage length is introduced when neck-down begins before failure. Platinum resistance furnaces can heat to 2700° F., but are expensive and do not provide the rapid heating rates that are needed.

Heating Elements Are Quartz Lamps

The essential item in our furnace is the G.E. T-3 quartz pencil lamps. As Fig. 1 shows, these lamps are partially imbedded in semicircular grooves machined in the reflector housing. This housing (of gold-plated copper) and the electrical

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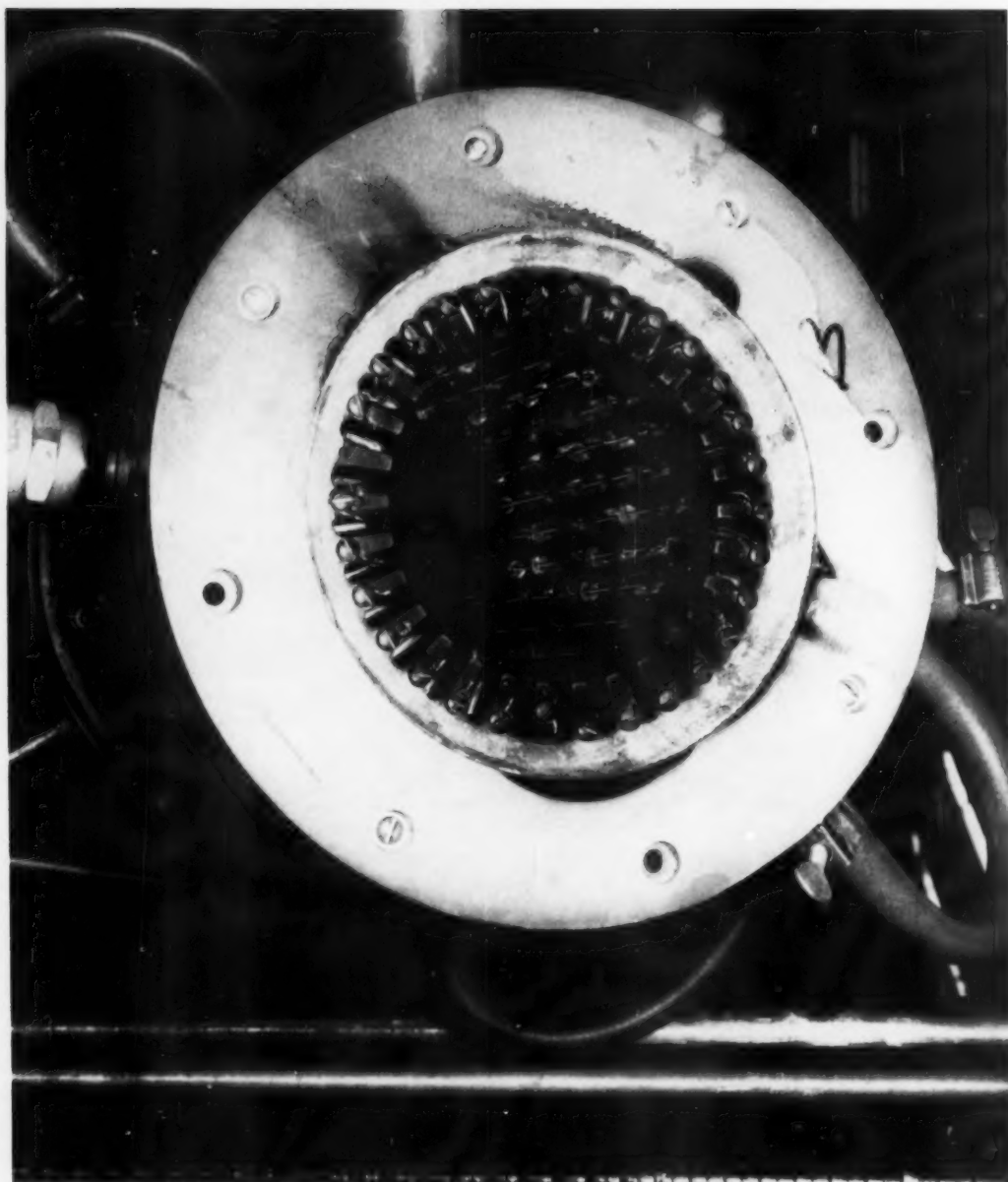


Fig. 1 - Chamber of Furnace Showing T-3 Quartz Pencil Lamps. The housing (of gold-

plated copper) and the electrical seals at the lamp ends are cooled by purified water

seals at the lamp ends are cooled by purified tap water which circulates through the housing walls and the power connectors.

All metal parts are machined from electrolytic copper and joined by silver brazing. An epoxy resin, which is heat resistant, provides electrical insulation. Environmental adaptors and hous-

ings for the stress-strain accessories are made from weldable aluminum alloy.

The internal bore of the furnace is $4\frac{1}{2}$ in. in diameter by 10 in. long, and holds 30 (500-w., 115-v. a-c.) T-3 quartz pencil lamps. Internal grooves of the reflector housing are plated with gold to prevent corrosion and provide good

reflectivity. A schematic sketch, shown in Fig. 2, describes the components of the furnace and accessories.

Power and Control Requirements

Although each lamp is rated at 500 w., it can be operated up to about twice the rated voltage; maximum power for the furnace is about 37,500 w. Replacement with double wattage filament, 1200-w. lamps permits the furnace to operate as

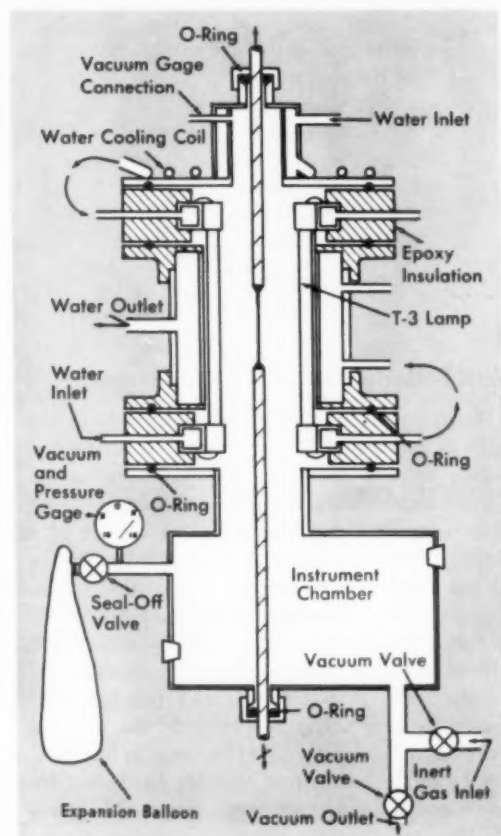


Fig. 2 — Schematic of Radiant Heat Furnace. The balloon is a safety feature. As the furnace heats, the atmosphere in it expands. The balloon then expands to accommodate the larger volume

high as 108,000 w. Temperature is controlled and recorded by an ignitron controller in conjunction with a Speedomax recorder.

When operated as rated, the lamps will last more than 5000 hr. However, to obtain 3000° F. in the specimen, power output must be slightly more than the rated capacity. Fortunately, this

has not harmed lamp elements even after continuous operation for several hours. For faster heating and temperatures above 3000° F., the lamps can be operated up to maximum power for a minute or more without apparent bad effects.

We obtained very good results from a temperature survey on a typical tensile specimen. With seven Chromel-Alumel thermocouples attached at half-inch intervals along the gage, and temperature control maintained on the thermocouple at the center of the gage, a maximum temperature difference of 20° F. was measured at either end after a 1-min. soak. Though this was excellent, we expect temperature distribution along the gage to be much more level with longer lamps.

These lamps have other advantages. For example, low mass inertia of the tungsten element permits instantaneous radiant heat. The lamp elements can be operated up to 5800° F., and the T-3 lamps will work in almost any atmosphere, and are readily available in various sizes and power capabilities.

Some Design Problems

Though these lamps appeared to answer most of our questions, certain undesirable features had to be designed out of the furnace. The end seals (where electrical leads protrude from the inside of the lamp envelope) could not be operated above 650° F. in air. Also the softening temperature of the quartz envelope is about 3000° F.; its melting point is 3193° F. Both problems were solved by providing water cooling in these zones. However, if this furnace is used in areas with relatively impure water, the water must be purified before it is used for cooling.

A hazardous feature of the furnace is the high voltage required for its operation. Personnel must be thoroughly familiar with the furnace and its controlling and recording equipment to minimize the potential danger.

Wide Use Is Possible

This furnace can be readily adapted to oxidation and recrystallization studies under various simulated conditions of altitude and temperature. We can also evaluate the effects of transient heat on insulation and thermal stresses on various components. Many other projects are possible. In fact, with the wide range of temperatures and atmospheres that can be obtained, this furnace should become more and more useful as a research tool.

Forming Cones by Metal Gathering

By H. P. TARDIF*

THE DEFORMATION MECHANISM of explosive or high-energy-rate forming is not yet understood. In making dome-shaped parts, it can be described as one of rapid deep drawing because walls of the domes are thinner than the original blank—a characteristic of deep drawing. A different response occurs when the workpiece is recessed in the die cavity, as in Fig. 1, rather than being placed over the die as is the conventional procedure. The walls of the part will contain regions which are thicker than the original blank. We call this particular response metal gathering.

Explosive forming of copper blanks in the modified setup produced shapes shown in Fig. 2. The blank was 3 5/16 in. in diameter and 1/8 in. thick. Only the weight of the explosive charge and the length of the confinement tube were changed to produce the various forms.

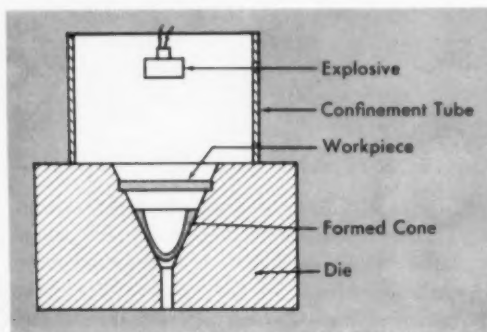


Fig. 1 (Above) — Modified Explosive Forming Setup. The workpiece has been recessed in the die cavity rather than being placed over the die as is the conventional procedure

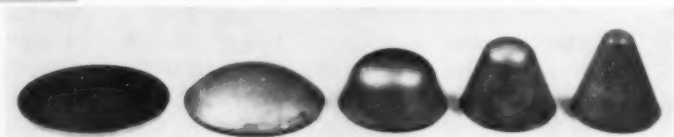
Cones can be formed without danger of rupture by recessing the flat workpiece in the die cavity rather than over it. Side effects cause the metal near the base of the cone to be thicker than the original blank. (G4b; NM-k34)

Metal Gathering Increases Wall Thickness

Hardness and thickness measurements in the walls of these shapes show that blanks respond in two ways to the forming pressure. For example, hardness and thickness measurements taken across the longitudinal cross section of a copper cone are plotted in Fig. 3. In part of the cone, the wall thickness exceeds that of the original blank—metal gathering has taken place. At the apex, deep drawing has made the wall thinner than the workpiece. The hardness of the zone of "zero deformation" (no apparent change in wall thickness) exceeds the original hardness of the blank. The increase in hardness may be attributed in part to work hardening by the passage of the stress wave. It is also prob-

*Physical Metallurgist, Canadian Armament Research and Development Establishment, Valcartier, Quebec.

Fig. 2 — Shapes Made in the Modified Setup by Varying the Explosive Weight and the Length of the Confinement Tube. The original workpiece at left is 3 5/16 in. diam. and 1/8 in. thick



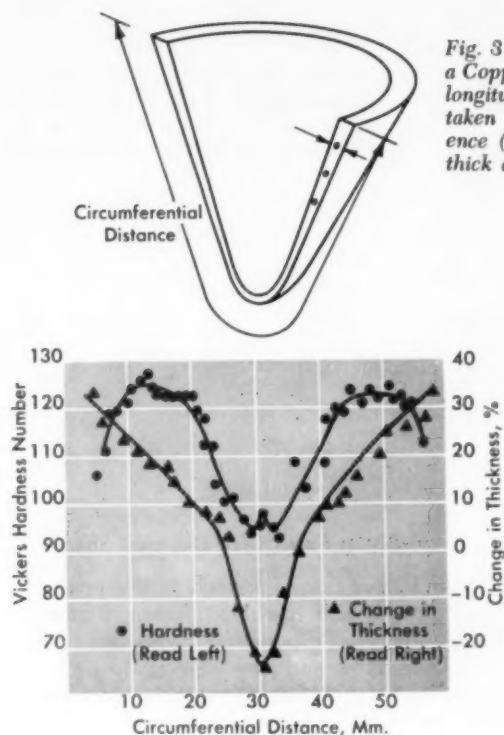


Fig. 3—Hardness and Thickness of the Walls of a Copper Cone. The cone was cut in half through longitudinal section and measurements were taken at specific distances along its circumference (see inset). The original blank was $\frac{1}{8}$ in. thick and had a Vickers hardness number of 50

able that in this region of "zero deformation" both metal gathering and deep drawing have occurred. The net effect: no apparent change in thickness but an increase in hardness. We have also found that, for the same amount of deformation, the change in hardness in the metal gathering zone is much higher than in the area of deep drawn metal.

Metal gathering may be significant in forming cones and dome-shaped parts. For example, some present applications require welding the workpiece in a conical shape before explosive forming. A flat workpiece either ruptures or does not fill the die cavity. Metal gathering would permit fabrication of cones directly from flat blanks. A more uniform product would result, and quality of the weld would not determine either formability or service reliability. ☹

Making Compacts by Explosive Forming

By E. W. LaROCCA*

The method finds a new use in a compacting press. Acting through pistons, the explosive force compresses powders and solid materials. (G1, H14; NM-k34)

MUCH OF THE INTEREST in explosive forming centers around its potential use in fabricating hard-to-work sheet metal alloys. We have investigated a technique for utilizing explosives in a double-piston press to compress powder or solid samples. A simplified diagram of the press is shown in Fig. 1. Its design includes provision for cylinders of explosives, each 1 in. diameter and 1 in. high. Simultaneous explosion of charges drives the pistons by means of the buffer plates and compresses the sample. Parts will not be contaminated by the explosive because the force is transmitted to the workpiece or powder by the buffer plates and pistons.

We prepared compacts from sponge cobalt, coarse titanium filings, and solid graphite disks. The cobalt sample was compressed to a homogeneous disk 0.012 in. thick. After forming, the density of the titanium compact was only 5% less than that of the original bar from which the filings were obtained. The graphite workpiece was a solid disk, 1/16 in. thick, machined from a $\frac{1}{2}$ -in. diameter bar. Compression increased its diameter and density without cracking it.

*Physics Div., Research Dept., U. S. Naval Ordnance Test Station, China Lake, Calif.; now on leave at the U. S. Naval Postgraduate School, Monterey, Calif.

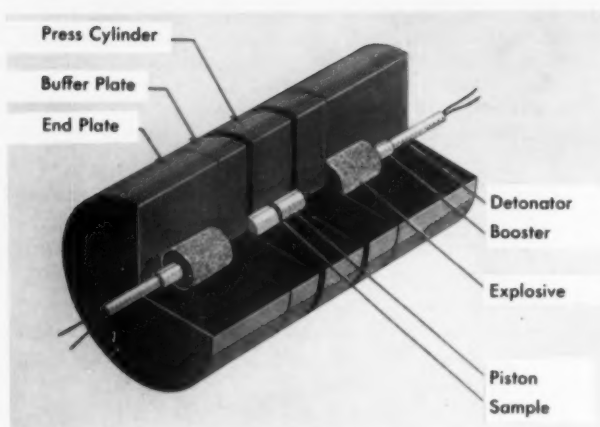


Fig. 1 - Cutaway Drawing of the Compacting Press. Forces from the simultaneous explosion of the charges are directed to the sample through the buffer plates and pistons

Ductile Binders Required

Further tests have shown that the powdered starting material should contain at least one ductile ingredient to prevent brittleness of the formed disk. For example, a compact of diamond powder and coarsely ground silicon appears to be a coherent solid, but the disk crumbles when removed from the press. On the other hand, a mixture of black oxide with powdered aluminum added as a ductile binder formed a strong, solid disk. Titanium carbide, usually hard and brittle, can be formed into a coherent disk if nickel is present.

Machined Piston Faces Give Different Shapes

Other shapes can be formed in the press by using pistons with machined faces. Figure 2 shows examples of pistons and the resulting compacts. The cross and ring were made from titanium and iron filings; the disks were formed from powdered calcite and cobalt. Various shapes have been produced from other materials, but we sometimes experienced difficulty releasing the compacts from the pistons. Dry lubricants, such as a molybdenum sulphide-graphite mixture, prevent sticking when applied to the faces but purity of compact is sacrificed. ☼

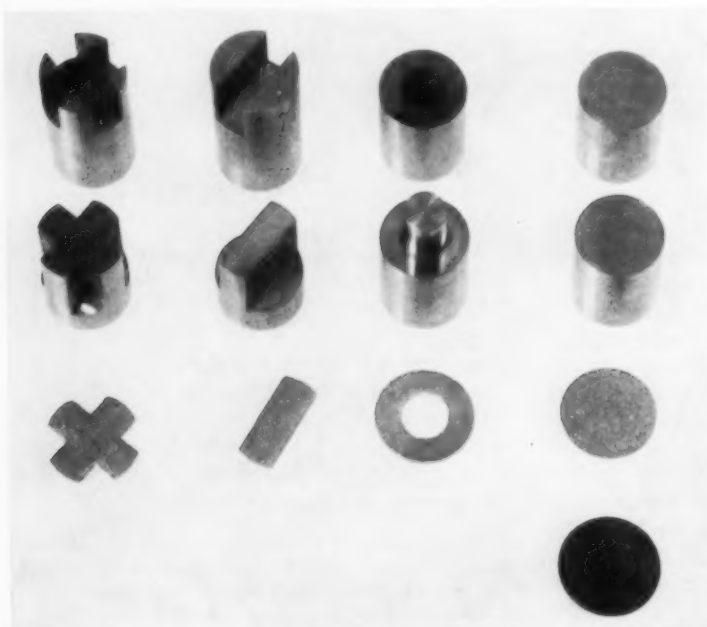


Fig. 2 - Piston Faces Can Be Machined to Give Shaped Parts. Compacts below are made of titanium and iron filings, powdered calcite and cobalt

A New Tool for Case Carbon Evaluation

By ALAN GOLDBLATT*

A direct-reading, vacuum spectrograph can be used to determine the carbon gradient in steel. This method is compared with analyses of carbon by combustion. (S11k, 1-53; ST, C)

DIRECT-READING SPECTROGRAPHS (Quantometers) have been used industrially since 1946. Their utility for complete ferrous analysis has been hindered because two significant elements in iron and steel—carbon and sulphur—cannot be routinely analyzed. These elements cannot be determined because their principal and most sensitive lines are located in the region of the spectrum where air absorbs most of the emitted radiation.

These problems have been overcome with a vacuum direct-reading spectrograph, the Quantovac, developed by Applied Research Laboratories. The instrument operates under vacuum, to minimize air absorption. Prior to making an analysis, the sample chamber (Fig. 1) is flushed with argon for 20 sec. This simplifies the loading problem and excludes the need for a vacuum seal in the sample chamber. The Quantovac has been used to analyze carbon steels, low and high-alloy steels, and cast irons. It can analyze 23 elements simultaneously with a complete analysis every 2 min. Precision is comparable or better than routine analysis by other methods (see Table I).

In cooperation with Diamond Chain

Co., Inc., Indianapolis, Ind., carburized specimens were analyzed to see if this method was sufficiently accurate for measuring case depth.

Carburized specimens were analyzed by the

*Consultant, Applied Research Laboratories, Inc., Glendale, Calif. Thanks are extended to George J. Shubat, chief metallurgist, Diamond Chain Co., and his staff for supplying the case hardened specimens, for performing the combustion carbon determinations, and for correlating the data. Acknowledgment is made to John Odom, Applied Research Laboratories, Inc., for the Quantovac analyses.

Table I—Precision Data on Quantovac Determinations

	SAMPLE 1161			SAMPLE 1162		
	CONC. *	S.D. †	C.V. ‡	CONC. *	S.D. †	C.V. ‡
Carbon	0.15	0.0017	1.2	0.40	0.0039	0.97
Phosphorus	0.053	0.0006	1.1	0.045	0.0011	2.4
Sulphur	0.019	0.0005	2.6	0.019	0.0005	2.6
Manganese	0.36	0.0034	0.94	0.94	0.0047	0.50
Silicon	0.047	0.0015	3.1	0.28	0.0021	0.75
Copper	0.34	0.0056	1.6	0.20	0.0027	1.3
Chromium	0.13	0.0012	0.92	0.74	0.002	0.27
Molybdenum	0.30	0.0016	0.53	0.08	0.0017	2.1
Nickel	1.73	0.009	0.52	0.70	0.0028	0.40

*Concentration of element in per cent.

†Standard deviation expressed in concentration.

‡Coefficient of variation, standard deviation in per cent of amount present.

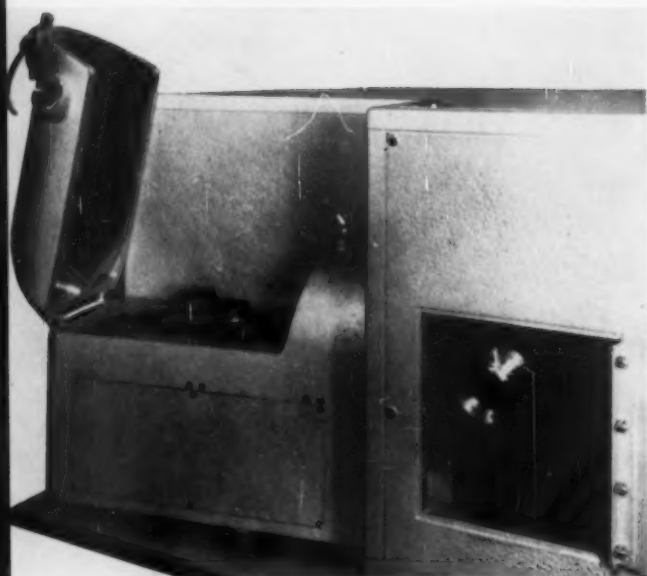


Fig. 1—The Sample Chamber of the Vacuum Spectrograph Is Flushed With Argon for 20 Sec. Before Making an Analysis. The spectrograph operates under vacuum to minimize air absorption

Quantovac using a point-to-plane technique. The counter electrode was a commercially available fine silver rod, $\frac{1}{4}$ in. diameter, which is pointed to a 120° included angle by means of a lathe. The spectrographic discharge samples an area which is about $\frac{1}{4}$ in. diameter and penetrates into the specimen surface some 0.001 in.

This permits local sampling and also allows a number of determinations to be made at various levels during a case depth study, if the surface

area permits. The combustion method for determining carbon, in comparison, requires 0.5 to 1 g. of metal for each analysis and is therefore an average analysis at each level.

Three specimens 9/16 in. diameter by $2\frac{1}{2}$ in. long of A.I.S.I. 4322 steel were carburized to a depth of 0.030 to 0.040 in. and oil quenched. These specimens were analyzed by the following procedure: A piece $\frac{3}{4}$ in. long was cut from each sample with a carborundum cut-off wheel, then clamped individually in a V-block and skimmed with a Reed precision surface grinder, until the sample would not rock on the surface plate. This surface was identified as the zero level. Carbon analyses were made with the Quantovac at 0.002-in. levels throughout three pins. These specimens were also analyzed by the combustion method, using a Leco carbon determinator.

Results of Analyses

A comparison of results is given in Fig. 2. The combustion determinations are superimposed on the Quantovac results. At each position, the combustion result appears as a single point, since it was necessary to combine turnings from the three test specimens to obtain sufficient metal for an accurate analysis. The data are in close agreement for both methods of analysis. They would be even closer if an allowance were made for the preliminary grind to flatten the pin prior to the Quantovac determinations.

The vacuum direct-reading spectrograph offers a sensitive and accurate method for determining carbon content of case hardened parts. It has many other potential applications in controlling heat treating processes, and in research and development.

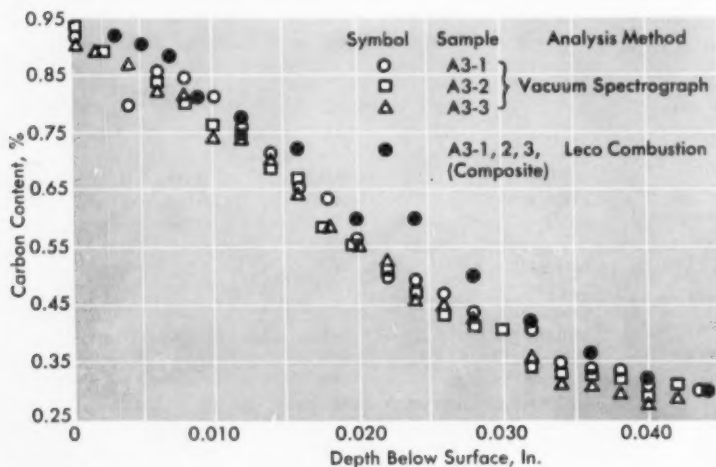


Fig. 2—Vacuum Spectrograph Method Compared With Conventional Combustion Analysis of Carburized A.I.S.I. 4322. Cylindrical specimens were 9/16 in. diameter by $2\frac{1}{2}$ in. long

New Techniques Broaden Forging Picture—II

*By J. H. JACKSON and H. B. GOODWIN**

Cored forgings, a unique multiple-ram forging technique, high-energy forming and improvements in conventional methods are helping to make better forgings at lower cost. Further advances are expected from fundamental studies of the forging process though research is still in the early stages. (F22)

LAST MONTH, the second in this series of articles discussed five new forging developments: the counterblow hammer, the "impacter", the "precision forging" process, the "continuous grain flow" process and roll forging. This article will give details of developments in cored forgings, multiple-ram techniques, and high-energy forming. Improvements in conventional equipment and progress in research will also be discussed.

Cored Forging

Originated in England for making brass plumbing fixtures (elbows, tees, crosses, and the like), this process has also been used to form a wide variety of parts from copper, aluminum, bronze, aluminum alloys, unalloyed titanium, and other materials.

Formerly, hollow or tubular components were machined from conventionally forged blanks. Since it is obviously more satisfactory to forge the hollow into the part, the cored forging process was developed. Briefly described, coring punches, one or more, are forced into the heated billet while it is held in closed and locked dies. The displaced metal flows out against the die surfaces, conforming to their shape, and the interior hollows are formed by the punches. Figure 1 illustrates a typical part.

The main difference between cored and solid forging is in the way pressure is applied. In solid forging, pressure is exerted by closing the die halves, whereas in cored forging it is exerted by the coring punches. Cored forging is commonly carried out in mechanical presses, and split dies are frequently employed.

Complex parts are made by using several

coring punches which may operate in different planes. Up to four cores in a single plane may be produced. Cores need not be round in cross section but may have any shape, and a short section at the end of any core may have a different (but smaller) shape than the rest of the core. Since coring punches must not be allowed to meet during forging, hollows are always blind ended. For such parts as plumbing fittings, punches can come close enough so that very little metal needs to be drilled out.

There are some design limitations. Core size must be proportionate to the piece—in other words, large enough so that the displaced metal will fill the die opening. Minimum wall thickness is about 0.10 in. Advantages are:

1. Very close tolerance—accuracy to 0.005 in. is possible.
2. Substantial saving of metal—subsequent machining is minimized.
3. No draft required—forging may have parallel walls.
4. Complex shapes easily handled.
5. Excellent properties in the metal—this type of working produces ideal grain flow.
6. Elimination of porosity.
7. High production, low cost.
8. Excellent die life (for brass, up to 100,000 pressings with repolishing after every 15,000 pressings).

*Mr. Jackson is manager and Mr. Goodwin is consultant, metallurgy department, Battelle Memorial Institute, Columbus, Ohio. This is the last of three articles on the forging industry today. Industrial trends were discussed in the first article (July 1959), while last month's and this one cover some of the newer forging developments.

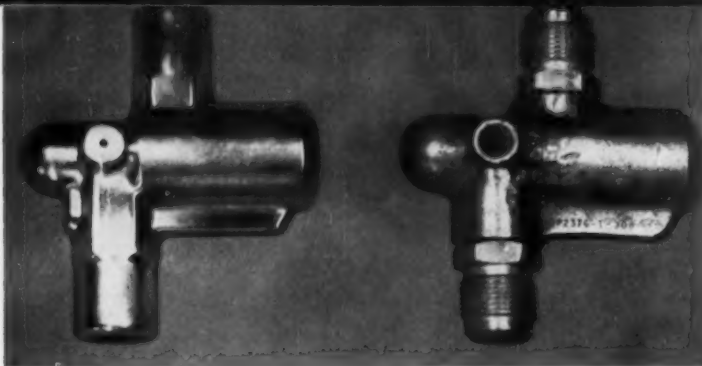
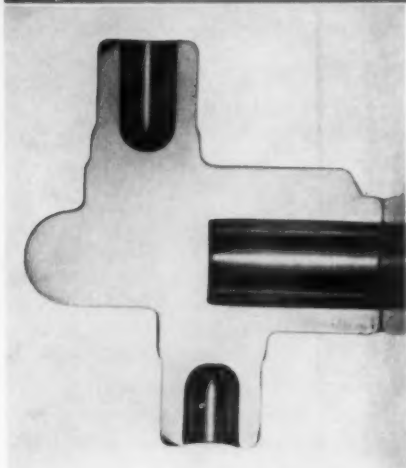


Fig. 1—The One-Piece Cored Forging Has Replaced the Four-Piece Cast Assembly on the Right. Lower view shows location of cores; parts were produced from a round brass rod by one blow of a 200-ton press. (Courtesy Bridgeport Brass Co.)



Multiple-Ram Technique

A unique method for making intricate forgings of heavy steel has been developed by Cameron Iron Works, Houston, Tex. Announced in the early 1950's, this process was developed mainly for making heavy oil well fittings, but it is adaptable to a wide range of parts. Bosses, flanges and cavities, and shapes which include a number of angled holes and orifices, are easily formed so that little machining is required.

Key to the process is a huge multiple-ram hydraulic press. It incorporates an 11,000-ton main vertical ram, two opposed 6000-ton horizontal side rams, and a 3000-ton auxiliary ram for piercing and similar operations. For most forging, the side rams hold split dies together while the vertical ram forces metal into the die cavities in a confined upsetting operation. After a blocking operation by the main ram, the auxiliary piercing ram may force a relatively small punch into the hot metal. This displaces the metal under high pressure to all corners of the die cavity. When this auxiliary piercing ram is used in this way, the process is identical in principle to the cored forging process discussed in the previous section. The auxiliary ram and sometimes the side rams are also used for backward extrusion of metal around the rams

to form certain parts. A special manipulator transfers the heated billet from the heating furnaces to the press.

Figure 2 shows a multiple-ram forge producing an interceptor valve for a steam turbine. The inset shows horizontal and vertical forging combined in one operation. Advantages are:

1. Intricate shapes, including hollow parts, can be made.
2. Little machining is needed.
3. Favorable grain flow produces excellent properties.
4. Operation is economical.

High-Energy Forming

In the past two or three years, explosive forming and other processes which use high deformation rates have attracted attention. So far, most studies have involved cold forming methods for sheets and plates, though a little work has been done on high-velocity hot forming. So many claims and counterclaims have been made for explosive forming that it is difficult as yet to assess the merits of the process. As an example, many investigators claim that metals flow like liquids at extremely high deformation rates. Consequently, less total energy and lower loads are needed for a given amount of deformation. It has been said that metals take the desired shape "before they have time to resist".

Explosive forming is being developed quite extensively by the aircraft builders because it offers much promise in forming large parts from high-strength sheet. Energy is supplied by explosives, or gas at high pressure. One of the attractive features is low equipment cost. Some methods need nothing more than a tank big enough to hold the die and blank. Only a female die is required; the blast forces the metal into it.

There is probably an optimum deformation rate for each operation and for each metal which will have to be established through research. One problem that is causing some trouble is the maintenance of thickness tolerances.

Metals that have been formed successfully include carbon, alloy and stainless steels, aluminum alloys (both annealed and hardened) and titanium. "Spring back" is virtually eliminated in materials that are explosive-formed; this is an added advantage.

A novel system of high-velocity forming, known as the "Dynapak" process (see Fig. 3), was exhibited at the 1958 National Metal Congress in Cleveland by the Hyge-Convair Div. of General Dynamics Corp.

The machine operates through differential gas pressure on two sides of a piston in a closed cylinder. The forging ram, equipped with con-

ventional dies, is attached to the piston. At the instant before the piston starts its stroke, low-pressure gas acting on a wide area on one side of the piston balances gas at much higher pressure but acting on a smaller area on the other side of the piston. On the high-pressure side, the piston rests against an orifice plate equipped with an O-ring seal; this prevents the high-pressure gas from exerting pressure on the entire piston area.

Gas pressure increases slowly on the high-pressure side. Finally, the equilibrium is upset. The piston moves away from the orifice plate, and the seal opens. *Instantly* the entire bottom area of the piston is exposed to the high-pressure gas. Since the pressure on the high-pressure side is many times that on the low-pressure side, the piston moves exceedingly rapidly—about 400 ft. per sec. Travel rate can be controlled by tapered metering pins which are attached to the high-pressure side of the piston and project through the orifice. Machines with 12-in. and 24-in. strokes and energy outputs ranging up to 360,000 ft.-lb. per stroke are offered.

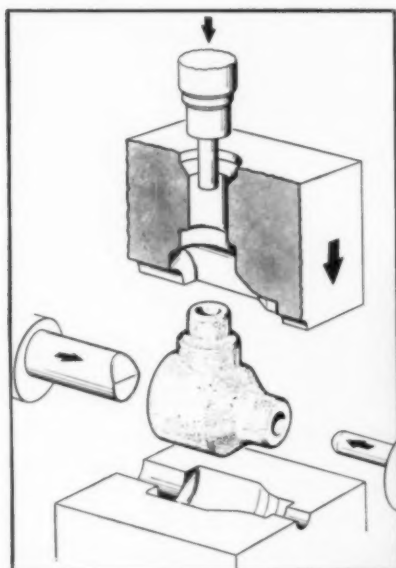
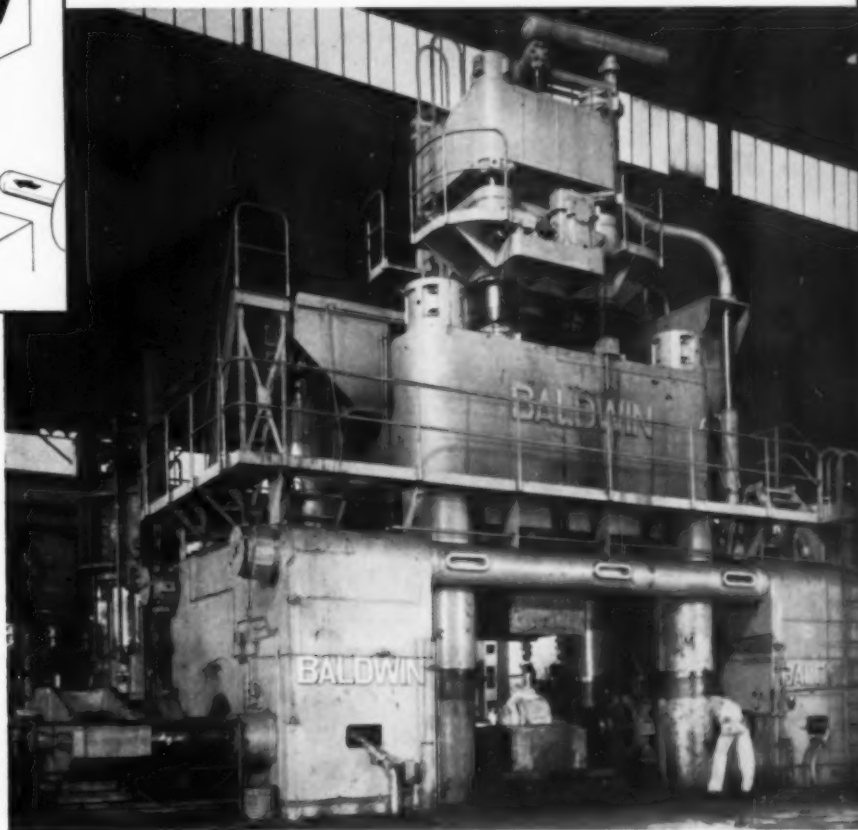


Fig. 2—A Multiple-Ram Forge Produces an Interceptor Valve for a Westinghouse Steam Turbine. Inset shows movement of rams. (Courtesy Cameron Iron Works)



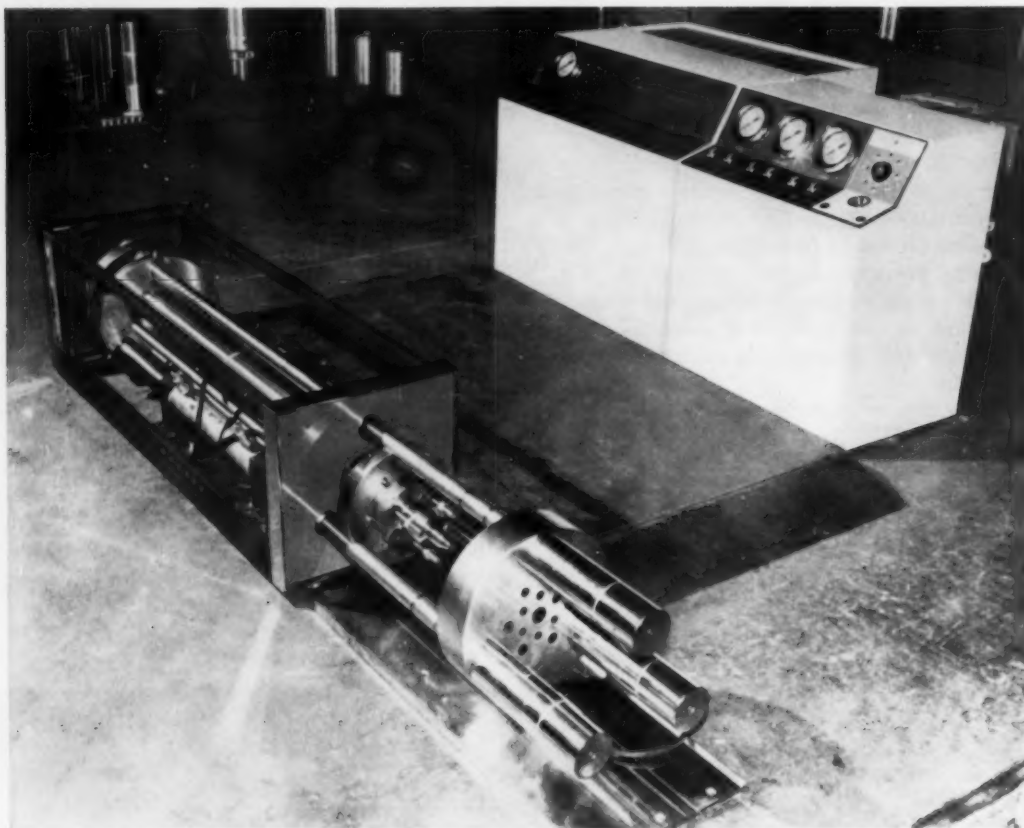


Fig. 3—High-Energy-Rate Tool for Forging Small Parts. (Courtesy Hyge-Convaair Div., General Dynamics Corp.)

Other Forging Developments

While these new forging techniques were being devised, there was also progress in traditional forging methods. Not only have hammers and presses increased in efficiency, but methods for making dies have become almost automatic.

At first glance, a modern steam drop hammer looks little different than the hammers of 100 years ago. This is also true of mechanical and hydraulic presses. All of them, however, are many times more productive than earlier models. One cause for this has been the trend to ever larger equipment. However, efficiency has also increased. Modern hammers and presses are vastly more productive than early models of the same nominal rating. For example, the 2000-lb. (usual nominal rating based on weight of falling parts) steam drop hammer of 1846 struck a 4500-ft.-lb. blow; with an anvil ratio of 5 to 1, forging efficiency was 5%, and the hammer produced 100 lb. per hr. of low-carbon steel forgings.

In contrast, a modern hammer of the same

2000-lb. nominal rating strikes a 27,000-ft.-lb. blow at a forging efficiency of 80%. It produces 650 lb. of low-carbon steel forgings every hour. The anvil ratio is 20:1, and the percentage availability is 90% (as opposed to 50% for the 1846 model). With the larger equipment being used, average tonnage production per man-hour today is 25 to 30 times what it was 40 years ago.

There have been three major improvements in the steam drop hammer since its conception by England's Nasmyth in 1838. First came impression dies, accurately machined to shape; these were devised by American firearm manufacturers at about the time of the Civil War. Until then, most forging had been done with flat dies, or occasionally with very crude impression dies. The second major advance was the advent of the double-acting steam hammer in Midvale, Pa., in 1888. In this, steam was used not only to lift the ram, but to exert additional force on

the downward stroke. As the third major improvement, a much better arrangement for steam valves was invented in 1933.

Starting in the early 1920's, the high-speed forging press was gradually developed to be useful for closed die forging. Older presses, designed for other purposes, were too slow and not rigid enough for this. Modern presses have been important in increasing forging productivity. A 2000-ton mechanical forging press will duplicate forgings produced on 4000-lb. steam and 5000-lb. board hammers.

In 1958, a fully automatic 2500-ton mechanical press, built by the Erie Foundry Co., was announced. In trials one man produced 1200 crawler track links per hr. on this machine; this was in contrast to 275 links per hr. formerly produced by three men on three hand-fed presses. Heating, feeding, forging, and delivery of the finished forgings could be accomplished automatically without assistance from the operator.

The upset forging machine developed in the 1880's has become larger, faster, more powerful and more rigid.

There is not space here to review the hundreds of minor improvements which have increased the productivity of these various machines. However, those listed show there is no stagnation in this industry.

Making Dies Automatically

Diemaking was originally a form of sculpture in hard metal. Excess metal was literally hacked out by hand, and machines could do little of the work. Gradually, tools especially designed for machining die cavities were evolved, until skilled machinists could do practically everything but the final dressing. In the early 1900's, automobiles, farm machinery, and other equipment began to be mass produced. The need for hundreds of thousands of identical forged parts gave rise to a similar need for many sets of identical forging dies. This led naturally to the conception of machines which would automatically duplicate a given die impression over and over without a human operator. Gradual progress toward this goal has been going on ever since.

The first development was the tracer-controlled die-sinking machine. First, an accurate model (plastic, wood or metal) of the die impression is made. The tracer on the machine scans the model and guides the cutter to duplicate the impression in the model in the die block being machined. The tracer and cutter move together and must be equally accurate. The first ma-



Fig. 4 - Automatic Die-Sinking Machine. After the machinist sets the machine, every operation is automatic. (Courtesy Cincinnati Milling Machine Co.)

chines were controlled mechanically and did little but rough out the impression.

About 1900, the Keller Mechanical Engineering Corp. (now part of Pratt and Whitney, Inc.) built the first mechanically controlled automatic die-sinking machines. By 1920, the electrical tracer-controlled machine had been designed.

In 1935, Cincinnati Milling Machine Co. introduced a die-sinking machine which was hydraulically controlled. This machine combined automatic depth control with automatic 360° profile tracing in a horizontal plane. All movements (longitudinal, transverse and vertical) were controlled from a single tracer finger. Figure 4 illustrates the machine in operation.

Today, many machine types are available. There are combinations in which two separate tracers are employed simultaneously with two separate masters, and machines which use templates rather than full masters. For simpler dies, many machines only control some of the machine movements automatically.

Many improvements have also been made in hand-operated die-sinking machines. They have become faster, more powerful, more rigid, and

more accurate. Semi-automatic controls have been added so that certain machine movements can be repeated automatically.

New Control Methods

With the recent appearance of electronic computers and allied techniques, new control methods have come into the picture for automatic machining of metals. In "numerically controlled" systems, punched cards, magnetic tape, punched paper tape or the like replace the model. Numerical control begins with a command (coded as numbers on tape or card) to move a machine member or to start or stop some operation. These control systems use "feedback". That is, some type of measuring system determines the exact position of the machine members at all times and feeds this information back to the control system.* Then the system compares input instructions with feedback data and makes corrections if needed.

So far, relatively little work has been done to adapt numerical control to die sinking. Wyman Gordon Co. has an experimental contract with the Air Force to evaluate numerical control versus tracer control for making forging dies. According to them, numerical control looks extremely good for two-dimensional control, but needs more work for three-dimensional control. At present, it takes longer to program a numerically controlled machine than to prepare a model for tracer control, but numerical control provides greater accuracy and speed for the machining operation. Speed is higher because, through proper programing, optimum feed rates and machine speeds can be used at all times. There is hope that programing time can be cut drastically as trained operators become available and as "libraries" of programs are built up for standard shape elements. Maintenance, a headache at first, is now said to be under control.

There is little question but that all the techniques for numerically controlled diemaking are available. Only economics — mainly cost of programs versus cost of models — will determine whether or not numerical control will come into widespread use.

Perhaps the most significant development of all is the research into fundamentals of the forging process itself.

*In cybernetic language, the machine has "closed loop control" — it is self-correcting. (Hand-operated machines have "open loop" control; feedback is provided by a human operator who measures the output — with micrometers, for example — compares it to a standard and adjusts the machine accordingly.)

ing process itself. Though studies are only beginning, some work has already been done on:

1. The effect of impact and pressure on properties of metal.
2. Metal flow in the plastic state (and the variables that affect it).
3. Studies of die friction, die wear, and lubricants.

These are examples only; the list is by no means as long as it could be.

With regard to the first item, we know that high pressure or impact greatly improves metal properties even in the absence of measurable metal flow.

Fundamental studies of metal flow have been approached from two points of view. The mathematical approach has been taken to determine the geometry of metal flow in relation to the stress system. However, many such studies have considered plastic metal flow in general, rather than any specific working process such as forging. The second approach is the attempt by metal physicists to determine the plastic properties of a metal from its atomic structure.

Numerous experimental techniques have been used to study metal flow. As one example, reference grids are marked on the specimen or on the interfaces of composite specimens. Grids are applied before working; deformation is determined by observing the distortion of the grid lines after working. Metal flow can be measured precisely by such methods. In other experiments, drilled holes are plugged with rods of different material, and the specimen is sectioned after forging to show movement of rods.

Other techniques are used; an interesting one for studying cold deformation is to observe the recrystallization behavior after rolling. This is based on the well-known principle that the most highly worked material is the most easily recrystallized. Hardness traverses and other mechanical property studies have also been used to estimate the amount of cold work. In addition, plasticine models, X-ray methods, two-phase alloys, analysis of internal flow from external shape and other techniques have been used.

Many studies have attempted to deal with die friction in a fundamental way. Also several studies of die wear have been made using radioactive tracer techniques.

The surface has only been scratched in studying fundamentals of the forging process. Nevertheless, progress has already been made. Much more should be done and will be done as time goes on.

MEMO:

To Metals Engineer:

*From improved finishing
may come the easiest
product improvement you
ever made...*

No. 2 in a Series on Better Finishing

Grinding and Polishing With Abrasive Belts

By W. K. SEWARD*

With a better understanding of basic principles, production men can put abrasive belts to their best use — keeping productivity high and costs low in many finishing operations. (G18, L10b, W25c; NM-j)

THE PAST FEW YEARS have seen a marked improvement in the performance of abrasive belts. Studies of grinding and polishing methods have shown that definite principles should be followed for best results. Hardness of the workpiece, its shape and size, the area to be ground and polished, amount of material to be removed, finish needed and dimensional tolerances allowed — all are factors which must be considered when choosing the components of an abrasive belt setup. The type of abrasive, contact wheel over which the belt runs, belt speed, lubricant or coolant — these also must be suited to the job because they influence cutting rate and belt life.

The ability of belts to remove metal rapidly is due in part to the uniform distribution of the grain on the backing. Abrasive particles are electrostatically deposited so that their best cutting edges extend away from the belt. Grains are anchored by a thin layer of adhesive which

leaves the greater portion of each of them exposed. The other key component which affects the cutting ability of abrasive belts is the contact wheel.

Role of the Contact Wheel

Contact wheels regulate the cutting rate and control the grain breakdown. Breakdown which is too rapid will quickly consume the grain; too slow grain breakdown will result in dulling or glazing and will cut down the stock removal rate. Contact wheel selection can alter cutting rate and belt life by 10 to 500%.

Not all wheels have the same "aggressiveness" — the ability to regulate cutting rate. For example, the simplest way to increase aggressiveness of a smooth contact wheel is to cut equally spaced grooves in its periphery. But other factors such as the hardness and diameter of the

*Supervising Engineer, Coated Abrasives Div., Carborundum Co., Niagara Falls, N.Y.

wheel, the number of grooves, and the ratio of land width to groove width also affect aggressiveness. Production experience and advice of those who deal in abrasive belts will help you select contact wheels to fit a specific job. Once a selection has been made and tried, the results obtained can be used in making adjustments in your grinding practice which will improve performance. Table I (Data Sheet, p. 96-B) suggests measures to correct specific problems.

Types of Contact Wheels

Contact wheels are made of cloth, canvas, leather, fiber, wood, metal, rubber, plastic or combinations of these materials (Fig. 2). Rubber and rubber substitutes make the best contact wheels for average grinding and polishing operations. Other materials may well be best suited for some applications. For example, laminated or sectional buff-type cloth contact wheels are good where maximum wheel flexibility is required. If the operation is such that edge wear of the wheel is high, the outside sections can be replaced at low cost. Compressed canvas wheels can be shaped to conform to a given contour. Metal or metal and rubber wheels are unexcelled for producing close dimensional tolerances and are best when heavy grinding pressures are required. (See Table III, Data Sheet, p. 96-B.)

Out-of-roundness of the contact wheel will have the same effect as an out-of-balance condition—both cause pounding or chattering of

the work. Belt life will be reduced, and final finish will be impaired. Dressing the wheel (Fig. 3) at operating speed corrects out-of-roundness.

Types of Backing

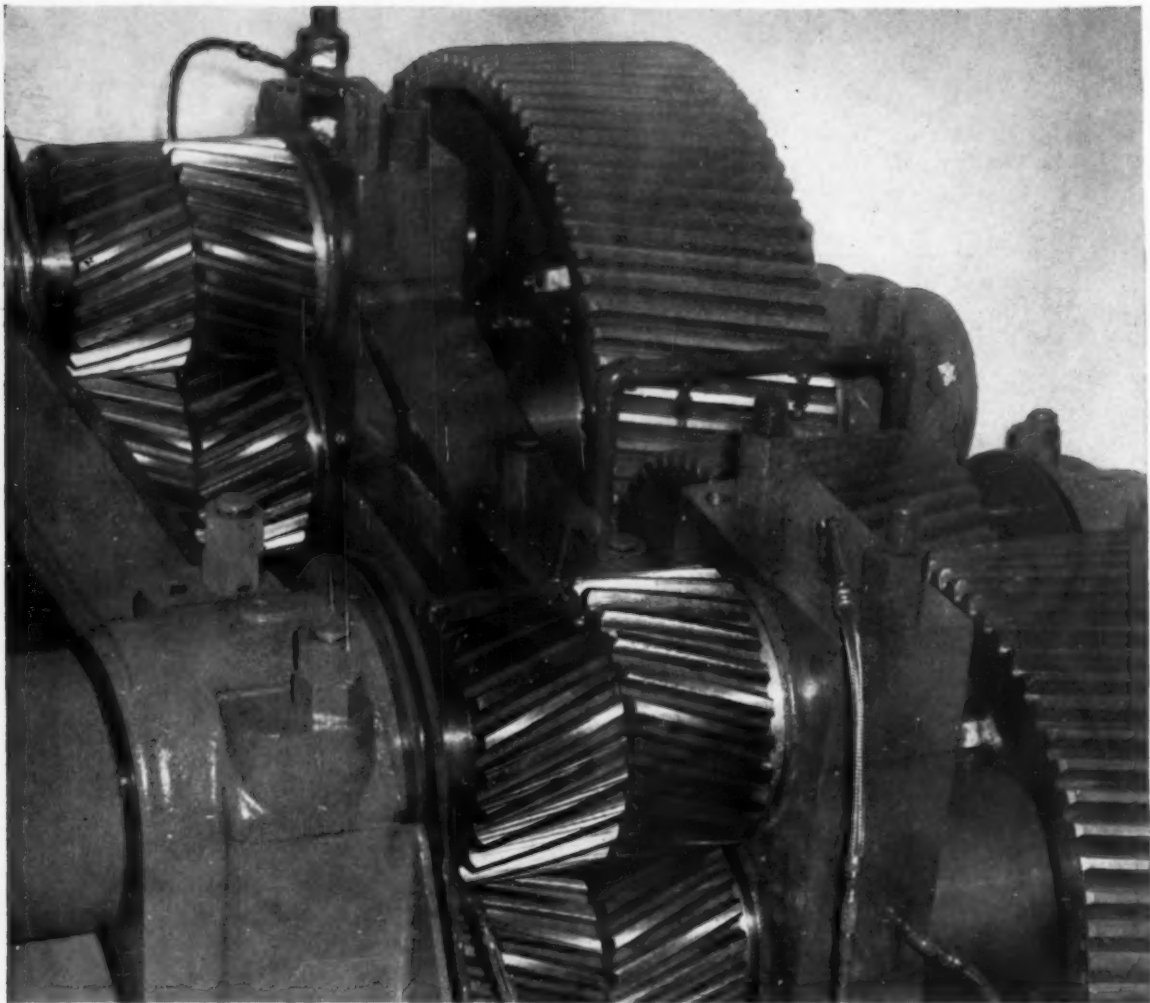
Cloth backings for abrasive belts are generally of two types: drills (X weight), which are the heavier and stiffer of the two; and jeans (J weight) cloths, which are quite flexible in comparison. The flexible J-weight backings are used for contour polishing where the abrasive belt and contact wheel must be deformed to follow the contours of the part. However, best belt life and fastest cutting are obtained with the heavy, stiff backing.

The stiffness of the backing can be altered by mechanical flexing or controlled cracking of the bond by the manufacturer. The industry uses two basic types of flexing. With one, the belt is run over bars placed 90° to the direction of travel; in the second, two bars, each placed 45° to the belt direction, are used to crack the bond. Both cracking procedures increase flexibility of the backing.

The type of bonding agent which is used to anchor the grains of abrasive to the backing plays an important part in belt life. There are six common bonds: all-glue, modified-glue, resin over glue, straight resin, synthetic varnishes, and modified resin. They increase in toughness and heat resistance in the order given. The hardness and toughness of the bond must be fitted to the



Fig. 1 — High Productivity of Abrasive Belt Grinding Is Advantageous in Foundry Operations. Quick removal of gate and riser stubs, and parting line fins is needed for economical production



Rolling mill pinions of Type 4620 nickel-molybdenum steel have a good hard case (500/550 Brinell) plus toughness, stand up to severe overloads. Made by Morgan Construction Company, Worcester, Mass.

4620 Nickel alloy steel gives them 4 times longer service

Hardened rolling mill pinions in an Eastern steel plant were not giving satisfactory service, due to continuous overloading. They just weren't tough enough to take the beating of heavy rolling.


Designers solved the problem — called for pinions of 4620 nickel-moly carburized steel ground after hardening. Now they've got a good case — pinions don't crack . . . tough cores support them.

This case stood up — the 4620 nickel alloy steel pinions have served over 4 times longer than the old through-hardened pinions . . . and are still going strong.

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Roughing and Polishing Metals With Abrasive Belts

Table I — Contact Wheel Adjustment Chart
Courtesy of Coated Abrasives Div.,
Carborundum Co., Niagara Falls, N. Y.

Table II — Recommended Grit Size, Belt Speed,
Lubricant and Contact Wheel Type
Compiled by Robert I. Chard,
Behr-Manning Co., a division of Norton Co., Troy, N. Y.

Table III — Contact Wheels and How They Work
Also Courtesy of Behr-Manning Co.

Table I—Contact Wheel Adjustment Chart

RESULT OBTAINED	SUGGESTED CHANGES											
	SOFTER	HARDER	NARROWER LANDS (WIDER GROOVES)	WIDER LANDS (NARROWER GROOVES)	HIGHER SPEED	LOWER SPEED	CHANGE LUBRICANT	DEEPER GROOVES	TRUE WHEEL	USE COARSER GRIT	USE FINER GRIT	CHECK MACHINE CONDITION
Belt glazed		X	X			X	X					
Belt loaded	X		X				X	X				
Too slow cutting		X	X			X	X	X		X		
Finish too coarse				X	X		X				X	X
Burning		X	X			X	X			X		
Too hard for contour	X		X			X		X				
Chatter	X		X					X				X
Shedding grain		X		X		X	X		X			
Dubs edges		X	X						X			

NOTE: All of the suggested changes checked for a given condition may not be necessary.

Table II—Recommended Grit Size, Belt Speed, Lubricant and Contact Wheel Type

MATERIAL	OPERATION	GRIT	BELT SPEED, SFPM.	LUBRICANT*	CONTACT WHEEL	
					TYPE	HARDNESS†
Hot and cold rolled steel	Roughing (a)	24-60 X	4000-6500	Dry or light-bodied grease, sulphur- chlorinated oil spray	Cog-tooth, serrated rubber	70-90
	Polishing (a)	80-150 X	4500-7000	Dry or light-bodied grease, sulphur- chlorinated oil spray	Plain-faced or serrated rubber X-serrated rubber or free belt	20-60
	Fine polishing (a)	180-500	4500-7000	Heavy grease or grease with abrasive compound	Plain-faced rubber or cloth	20-40
Stainless steel	Roughing (a)	50-80 X	3500-5000	Light-bodied grease or sulphur- chlorinated oil flood	Cog-tooth, serrated rubber	70-90
	Polishing (a)	80-120 X	4000-5500	Light-bodied grease or sulphur- chlorinated oil spray	Plain-faced or serrated rubber X-serrated rubber or free belt	30-60
	Fine polishing (b)	150-280	4500-5500	Heavy grease or oil mist	Plain-faced rubber or cloth	20-40
Aluminum, cast or fabricated	Roughing (c)	24-80 X	5000-6500	Light-bodied grease or sulphur- chlorinated oil spray	Cog-tooth, serrated rubber	70-90
	Polishing (c)	100-180	4500-6500	Light-bodied grease or sulphur- chlorinated oil spray	Plain-faced or serrated rubber X-serrated rubber or free belt	30-50
	Fine polishing (c)	220-320	4500-6500	Heavy grease or grease with abrasive compound	Plain-faced or X-serrated rubber or free belt	20-50
Copper alloys or brass	Roughing (c)	36-80 X	2200-4500	Light-bodied grease or sulphur- chlorinated oil spray	Cog-tooth, serrated rubber	70-90
	Polishing (c)	100-150	4000-6500	Light-bodied grease or sulphur- chlorinated oil spray	Plain-faced or serrated rubber X-serrated rubber or free belt	30-50
	Fine polishing (c)	180-320	4000-6500	Light-bodied grease or grease and abrasive compound	Same as polishing	20-30
Nonferrous die castings	Roughing (c)	24-80 X	4500-6500	Light-bodied grease or sulphur- chlorinated oil spray	Hard wheel depending on application	50-70
	Polishing (c)	100-180 X	4500-6500	Light-bodied grease or sulphur- chlorinated oil spray	Plain rubber, cloth or free belt	30-50
	Fine polishing (c)	220-320	4500-6500	Heavy grease or grease with abrasive compound	Plain face or X-serrated rubber or free belt	20-30
Cast iron	Roughing (a)	24-60 X	2000-4000	Dry	Cog-tooth, serrated rubber	70-90
	Polishing (a)	80-150 X	4000-5500	Dry	Serrated rubber	30-50
	Fine polishing (a)	120-240 X	4000-5500	Dry	Smooth-faced rubber	30-40
Titanium	Roughing (c)	36-50 X	700-1500	Sulphur-chlorinated grease stick or oil flood	Small diameter, cog-tooth serrated rubber	70-80
	Polishing (b)	60-120 X	1200-2000	Light-bodied grease	Standard serrated rubber	50
	Fine polishing (b)	120-240 X	1200-2000	Light-bodied grease	Smooth-faced rubber or cloth	20-40
High-temperature alloys ‡	Roughing (a)	24-50 X	4000-5500	Sulphur-chlorinated grease stick	Smooth-faced steel or cog-tooth serrated rubber	70-90
	Polishing (a)	40-100 X	4000-5500	Light-bodied grease	Serrated rubber	50
	Fine polishing (a)	100-150 X	4000-5500	Light-bodied grease	Smooth-faced rubber	30-40
S-816	Roughing (a)	24-50 X	4000-5500	Sulphur-chlorinated grease stick or oil spray	Smooth-faced steel or cog-tooth serrated rubber	70-90
	Polishing (a)	40-100 X	4000-5500	Light-bodied grease	Serrated rubber	70
	Fine polishing (a)	100-150 X	4000-5500	Light-bodied grease	Smooth-faced rubber	50

* Unless removed immediately after the grinding operation, sulphur-chlorinated lubricants may stain the workpieces. Emulsions and rust-inhibited water coolants are recommended when overheating of workpieces is a problem.

(a) Aluminum oxide is preferred abrasive.











(b) Silicon carbide is preferred abrasive.

(c) Both abrasives are satisfactory.

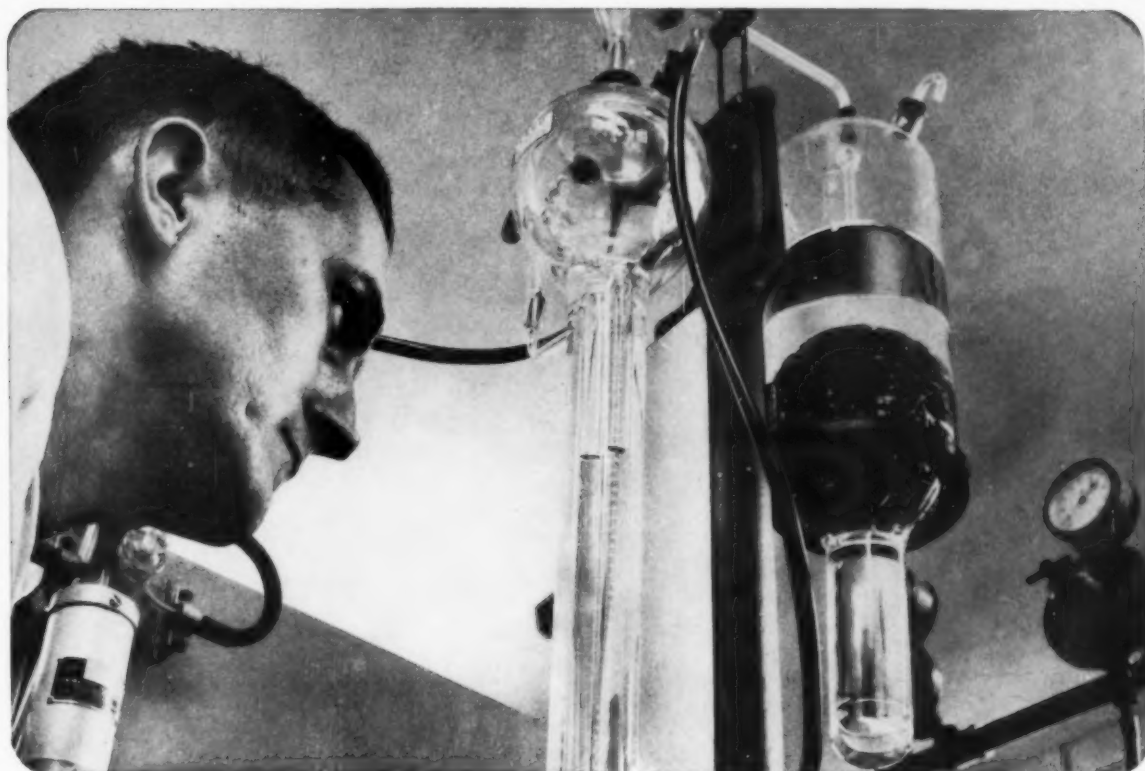
† Durometer scale. The Durometer reading is a measure of rubber hardness.

‡ Inconel X, Inconel 700, Nimonic 80, Nimonic 90, Nimonic 100, Stellite 27, Waspaloy, Hastelloy

Table III—Contact Wheels for Abrasive Belts and How They Work

WHEEL	SURFACE	MATERIAL	HARDNESS AND DENSITY	PURPOSES	WHEEL ACTION	APPLICATIONS
	Cog-tooth	Rubber	70-90 Durometer	Grinding	Fast cutting, allows long belt life.	For cutting down projections such as weld beads, gates, flares, sprues.
	Standard serrated	Rubber	40-50 Durometer, medium density	Grinding	Removes stock but leaves rough to medium ground surface.	For smoothing or blending projections or surface defects.
	X-shaped serrations	Rubber	20-50 Durometer	Grinding and polishing	Flexibility of rubber allows entry to contours. Medium polishes and light stock removal.	Same as standard serrated wheels but preferred for softer, nonferrous materials.
	Plain face	Rubber	20-70 Durometer	Grinding and polishing	Plain wheel face allows controlled abrasive grain penetration.	For large or small flat faces. Soft wheels give good finishes.
	Flat flexible	Compressed canvas	Nine densities going from hard to soft	Grinding and polishing	Hard wheels cut more slowly than cog-tooth rubber wheels.	Good for medium-range grinding and polishing. Soft wheels polish to fine smoothness.
	Flat flexible	Solid sectional canvas	Soft, medium and hard	Polishing	Gives uniform polishes. Avoids abrasive pattern on work. Adjusts to contours. Can be preformed for contours.	A low-cost wheel with uniform density at the face. Handles all types of polishing.
	Flat flexible	Buff section canvas	Soft	Contour polishing	For fine polishes and finishing.	Can be widened or narrowed by adding or removing sections. Low cost. For all types of polishing.
	Flat flexible	Sponge rubber inserts	5-10 Durometer, soft	Polishing	Gives uniform polishes and finishes. Polishes and blends contours.	Has replaceable segments. Polishes and blends contours. Segments allow density changes.
	Flat flexible	Rubber segments	Varies in hardness	Grinding and polishing	Grinds or polishes depending on density and hardness of inserts.	For portable machines. Uses replaceable segments that save on wheel costs and allow density changes.
	Flat flexible	Inflated rubber	Air pressure controls hardness	Grinding and polishing	Gives uniform finishes.	Adjusts to contours.

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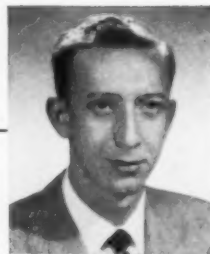
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500X

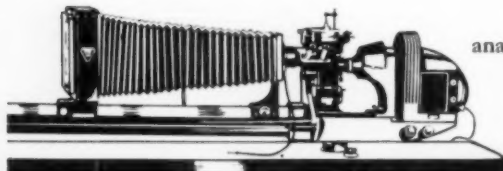
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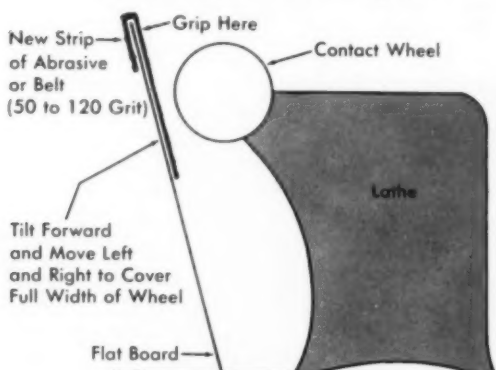


Fig. 2 — Contact Wheels Determine Performance of Abrasive Belts. Each is designed to regulate the cutting rate of belts in specific grinding and finishing jobs

type of operation being performed. In polishing operations which require light pressure, an all-glue or modified-glue bond is best. As stock removal requirements and grinding pressure increase, the harder and tougher bonds should be selected. Water can be used to lubricate any of the belts bonded with synthetic varnish.

The correct treatment of belt trouble requires

Fig. 3 — Dressing Contact Wheels Which Are Out-of-Round Will Result in Longer Belt Life and Better Finishes. Wheel should be dressed at its operating speed



an understanding of glazing and loading. These troubles point to incorrect components or procedures. The recognition of glazing and loading can lead to lower polishing costs because both defects result in early discarding of belts even though there is plenty of abrasive left.

Glazing occurs when insufficient grinding pressure is used or when the contact wheel is not aggressive enough to produce controlled grain breakdown. The tips of the grains wear smooth and become shiny through friction and sliding contact with the work. Corrective action calls for the use of a harder contact wheel or more grinding pressure to remove the shiny surface by fracturing the abrasive particles. Only then will new cutting edges be exposed. There is no need to throw away glazed belts, but it is best to correct the cause.

Loading looks like glazing and the two defects are often confused with each other. On a loaded belt, metal becomes smeared over or welded to the grains. It is most pronounced when a soft metal is being ground or when the part has a low thermal conductivity. There are plenty of sharp abrasive grains on loaded belts but their cutting ability is impaired by the smeared metal. Unless corrective action is taken (see Table I) belt life will be short and productivity low — your polishing costs will climb.

Lubrication of belts is one way to prevent loading. A lubricant increases the cutting rate



Fig. 4 — Brass Cases Are Given Final Finish in This Conveyor Belt Setup. Operation is continuous and cases are loaded in the holding fixtures while the conveyor belt is moving

and extends belt life by as much as six times that obtained when none is used. Of the three common types of lubricants—stick grease, oils, and water—the stick grease is more popular. It is convenient to use and effective when the metal particles are lightly attached to the abrasive. Grinding and machining oils, however, do a better job when severe loading is a problem. If the parts being ground or polished must be constantly cooled, water-soluble coolants which contain sulphur and chlorine compounds perform best.

Belt Speed

Laboratory and service tests show that the most effective speed for resin-bonded belts is 4000 to 7000 surface ft. per min. (sfpm.). Glue-bonded belts perform best at about 1000 sfpm. lower than those recommended for resin bonds. Generally, the harder the metal, the lower the belt speed. Low speed should be used with coarse grit sizes (60 or coarser); and, on the same metal, higher speeds are recommended when polishing with fine-grit belts (80 or finer).

Platen Grinding for Flat Surfaces

Flat surfaces can be rapidly obtained by grinding against a belt supported by a flat platen. Platen grinding is most successful if the metal is free cutting and if the part has a small or interrupted area of contact with the belt. Belt life and rate of cut are a function of the area being ground on platen operations. If the length of work in the direction of belt travel is greater than about $\frac{1}{2}$ in., chip interference between belt and work greatly reduces the rate of cut and belt life.

Few people know that abrasive belts, like

grinding wheels, can be dressed to maintain their cutting ability. Dressing is effective on belts of coarse grit (24 to 60) which have been used in platen grinding. The platen does not afford controlled grain breakdown as does a contact wheel and belts become glazed. Rather than discard the belt, life can be renewed by breaking down the grains with a star dresser.

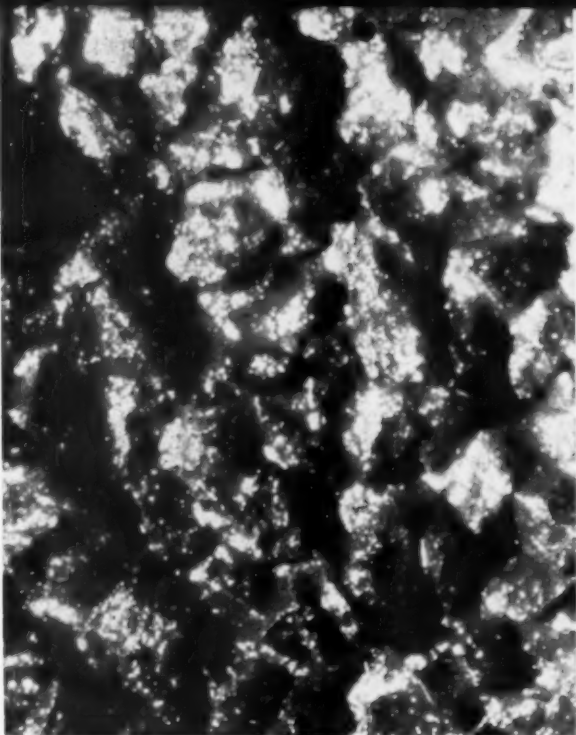
Dressing of belts which are used on contact wheels is not recommended. The function of a contact wheel is to regulate grain breakdown to expose sharp cutting edges. Thus, glazing on belts running on contact wheels is an indication that an improper wheel is being used. Long-range economy dictates corrective action suggested in the Data Sheet on p. 96-B.

Tolerances of ± 0.001 in. are readily held on many through-feed or conveyerized operations even when substantial stock removal is necessary. When fine grit sizes and light grinding pressure are used, tolerances in the range of ± 0.0005 in. are practical on a production basis. On other types of operations, such as roll grinding and centerless grinding, with suitable equipment, tolerances in the range of ± 0.0005 in. are relatively easy to hold and an over-all tolerance of ± 0.0001 in. has been obtained where the equipment was in excellent condition.

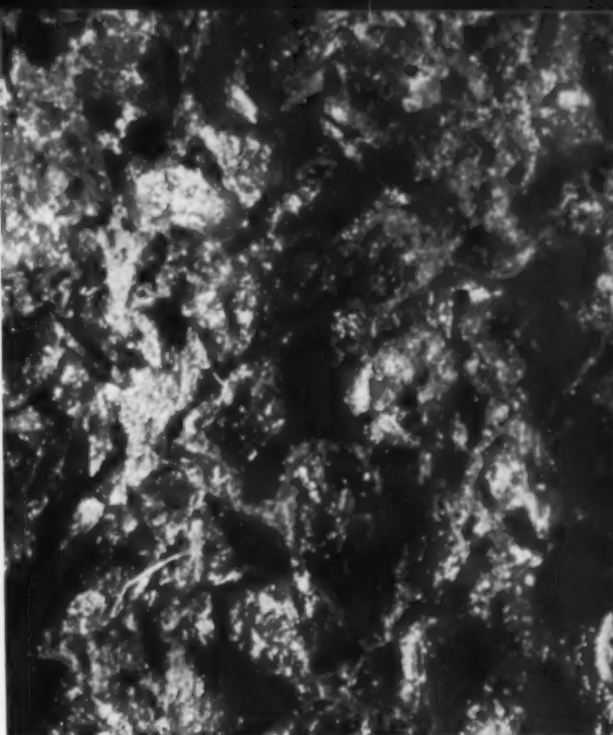
Nonferrous Metals

Most of the nonferrous metals are easily ground and polished with good belt life. It is not uncommon for coarse-grit belts, 3 to 4 in. wide, to remove over 100 lb. of metal before wearing out. The same belt would remove only 10 to 15 lb. of ferrous metal.

Loading is the most serious problem with nonferrous metals. Ductile materials are the worst



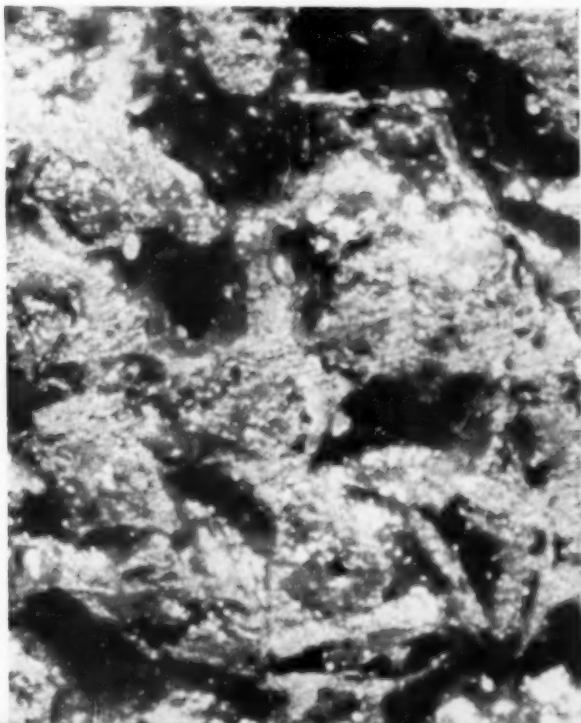
New Belt of 36-Grit Aluminum Oxide Bonded With Resin. Properly chosen contact wheels and lubricants will insure controlled grain breakdown without loading and glazing. 16 ×



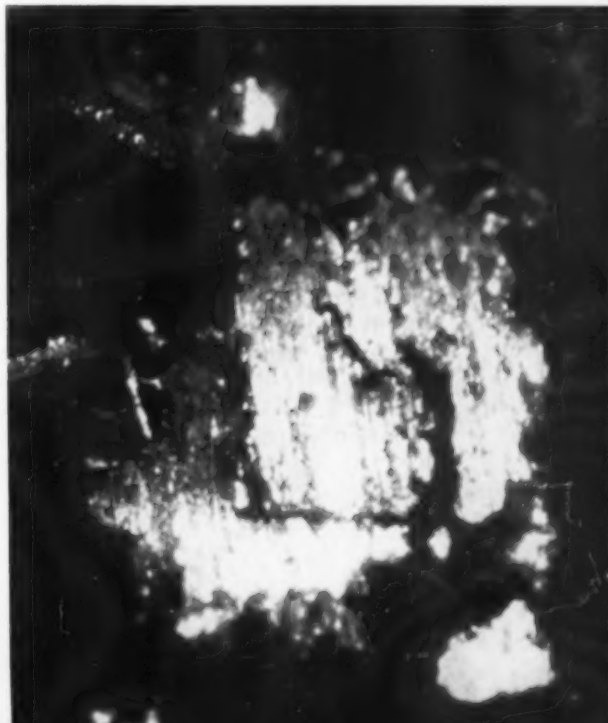
Used 36-Grit Aluminum Oxide Belt Showing Rapid Grain Breakdown. Dark areas are craters where abrasive grains have been pulled out of the bond. The contact wheel used with this belt was too hard. 16 ×

Microscope Pinpoints Production Problems in Belt Polishing

Surface of a Glazed Belt. Tips of grains have been worn smooth because inadequate grinding pressure or a soft contact wheel was used. Cutting rate is greatly reduced. This belt can be saved by switching to a more aggressive contact wheel or applying heavier pressure. 45 ×



Loading Occurs When Metal Becomes Smeared and Fused on the Tips of the Abrasive Grains. Note inadequate grain breakdown and pull out. Cutting edges have been covered and no new ones exposed. Best cure is lubrication or a harder contact wheel. Both may be required. 45 ×



offenders, but lubricants will minimize the problem. During hand operations when coarse grit sizes are used for rough grinding, lubricants may not be needed if the metal is hard and has good machinability. Some of the soft metals require application of grease of high melting point only when the belt is new; others require repeated applications of the grease. When a lubricant is needed, it should be applied to the belt before any grinding is done to prevent loading. Once the belt has become loaded no lubricant will restore its original sharpness.

Productivity during rough polishing with coarse grits and heavy pressure (2 hp. or more per in. of contact width) is higher when aluminum oxide rather than silicon carbide abrasives are used. When grit sizes between 24 and 120 are used with light pressure for rough polishing operations, silicon carbide grain will cut more rapidly and last longer than aluminum oxide. Aluminum oxide performs best in fine-grit polishing (150 and finer).

Mechanized operations perform most efficiently when a flood of compounded oil is used. Best flushing of chips and cooling of the work is obtained with light viscosity oils in the range of 80 to 150 SSU*. Paraffin-base mineral oils which contain 10% lard oil do a good job.

Neither oil nor water lubricants are as convenient to use as are grease sticks, but both are useful when particular problems arise. A flood of oil maintains cutting ability and gives longer belt life than other lubricants. Water has the best cooling ability and is recommended when overheating is a problem.

Tough bronzes and nonferrous materials such as Monel and Inconel should be treated the same as stainless metals.

Ferrous Metals

Aluminum oxide is used almost exclusively for grinding and polishing ferrous metals. One exception is in final finishing of stainless sheet. Here silicon carbide imparts a brighter surface with a slight bluish cast which is good for decorative purposes. The ease of grinding or polishing ferrous metals is related to machinability. Thus, leaded steels, which machine freely, are easily ground; hardened nickel steels are more difficult to machine and are also more difficult to grind.

Where a large amount of metal must be removed, it is most economical to use a hard contact wheel. The size, speed and aggressive-


ness of the contact wheel must, of course, be fitted to the particular job. For example, very hard materials or those which are covered with scale require a harder (90 durometer) and more aggressive wheel than unhardened metals with clean surfaces. When scale must be removed from contoured surfaces, it is better to use a wheel which is too hard than one which is soft enough to conform to the contours. True, the hard wheel may give an excessive cutting rate and cause flat spots, but belt life will be good. Flat spots can be blended out by a softer wheel after the scale is removed.

Lubrication is often vital but may be overlooked as a step to effective grinding and polishing. In grinding stainless steels, loading of belts is a problem but oils containing sulphur or chlorine antiweld compounds increase belt life. Generally, high alloys with greater toughness require more antiweld additives in the oil. On such materials a flood of oil is more effective than a mist or spray.

When loading is a problem in the nonstainless metals, a change to a harder and more aggressive contact wheel may be all that is required. This may even eliminate need for a lubricant.

Know Belt Limitations

While belts can do many operations faster and more economically than other methods, they are by no means a universal tool for all types of finishing operations. Obviously, a belt cannot be used for cutting. It is not economical to use belts for cleaning off fins when they occur in small radii, next to shoulders, or in right angles of castings and forgings. Grinding in these areas requires use of the edge of the belt and damages the cloth backing and the edge of the contact wheel. Grinding sharp projections such as fins is practical when the entire surface can be used.

Close-tolerance grinding with belts near shoulders, flanges, and changes in diameters is not recommended. The strength of the backing also limits the use of belts for severe grinding where levers and other mechanical aids run pressures higher than 5 to 6 hp. per in. of contact width. Like all tools, successful application of belts depends on proper choice of components. Choose the grade of abrasive, type of contact wheel, and lubrication to fit the job. Recognize the signs of inefficient performance in your grinding and polishing operations. The corrective measures you apply will help you achieve best results from abrasive belts—low-cost operation and a better finish for your product. 

*Seconds Saybolt Universal.

Potential for Oxygen in Steelmaking

*Special Report by E. C. WRIGHT**

Companies using the oxygen converter process and those experimenting with oxygen in blast furnace and openhearth report economies and increased production rates. Future need for more steel capacity at reasonable cost is expected to spark a boom in oxygen steelmaking techniques. (D-general, D10; O)

IN 1958, THE STEEL INDUSTRY used 28.8 billion cu.ft. of oxygen, an 11% increase over the record set in 1957. This increase occurred even though the steel industry operated at only 60% of capacity in 1958. (It operated at 84% in 1957.) Of the 28 billion cu.ft., 13 billion was used for steelmaking and 5.9 billion was used in blowing blast furnaces, according to *Steel Facts*, published by the American Iron and Steel Institute.

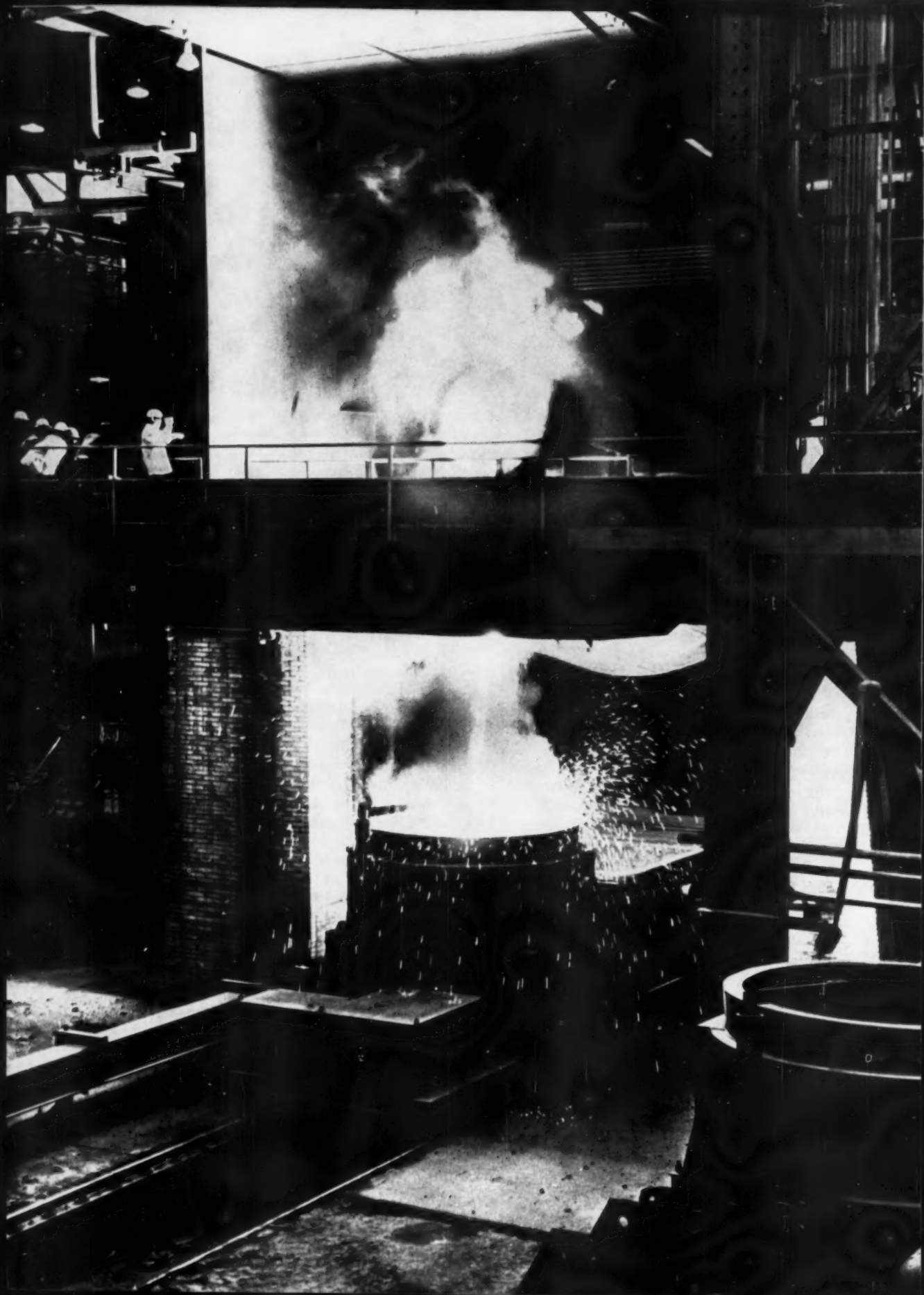
The total capacity of American steel mills in 1958 is given as 140,742,570 tons. If this total capacity were treated with oxygen in either the openhearth, electric furnace or oxygen converter, nearly 140 billion cu.ft. of oxygen would be needed. This approximates 5.82 million tons of oxygen. It is evident that the steel industry is only using about one fifth the oxygen that might be used for increasing steel production.

Again, according to American Iron and Steel Institute figures, the steel industry purchased 15,610 million cu.ft. from outside suppliers in 1958, while it produced only 5,559 million cu.ft. Apparently, only oxygen converter plants have their own oxygen plants. A 300 ton-per-day oxygen plant in a converter operation will produce about 1.5 million tons of steel in a year. Furthermore, in the 1957 to 1959 period the capacity of oxygen-blown converter plants has increased from about 500,000 tons to 4 million tons per year. (Several new plants of this type are in the

estimating stage.) Converter steel capacity, 4 million tons in 1959, will consume over 6 billion cu.ft. of oxygen per year.

The figures given above only consider steel manufacturing. If the use of oxygen in the blast furnace develops, which seems possible, the amount of oxygen required in a steel plant would be tremendous. An ordinary blast furnace uses about 100,000 cu.ft. of air per ton of pig iron produced, and if this air is increased from 21% oxygen (normal air) to 23½% oxygen (enriched air), the amount of oxygen required becomes fantastic. Since there are 91 million tons of blast furnace capacity in the United States today, enrichment of the blast to 23½% would require about 225 billion cu.ft. of oxygen. If this is added to the 140 billion cu.ft. required for steel production, a total consumption of 365 billion cu.ft. of oxygen is obtained. This does not include the oxygen used in combustion in the openhearth and several other applications. Potentially, this amount of oxygen might be used in the blast furnace and steel-melting industry in the future. Since only 28.8 billion cu.ft. of oxygen was used in 1958, the potential for added oxygen capacity becomes enormous. There might be an eventual requirement for 500 billion

*Head, Department of Metallurgical Engineering, University of Alabama; Consulting Editor, *Metal Progress*.



cu.ft. of oxygen; this amounts to 20,000,000 tons.

In an article in *Blast Furnace and Steel Plant*, May 1959, H. B. Emerick, technical director, Jones & Laughlin Steel Corp., listed the places where oxygen could be used to advantage in a steel plant. According to him, blast-furnace gas can be enriched to over 21% oxygen to reduce ore to metal, oxygen can be used to produce hydrogen for direct ore reduction, and metal from the blast furnace can be desiliconized before charging into the openhearth furnace. Also, oxygen can be used in the openhearth (to decarburize or enrich the air used for combustion to raise flame temperatures) and in the electric furnace (especially on stainless steel for decarburization). Finally, he mentions pneumatic processes. Bottom-blown converters or overhead injection L-D converters can use a good deal of oxygen.

In the steel industry, all these different methods are being employed, mostly on an experimental basis, to determine the effectiveness of oxygen in any given situation. All reports, up to the present time, indicate that oxygen definitely increases iron production in blast furnaces and steel production in openhearts and converters. These increases in production are of great value because less equipment (and, thus, less capital investment) is needed to increase production. Since steel capacity increases in the United States at about 4 million tons per year, these reported increases in production due to oxygen application are of great importance.

The use of oxygen reduces coke consumption in the blast furnace, and fuel, ore and lime consumption in the openhearth. Also, more scrap is melted in the converter without fuel. The decrease in material and labor costs, due to increased production per hour, must be balanced against the cost of oxygen. No one will commit himself as to the cost of oxygen, since it varies with the purity, size of oxygen plant, and whether it is purchased from one of the large oxygen producers. The only sensible figures supplied the writer are about \$0.50 per ton in an L-D converter using 1500 to 1600 cu.ft. of oxygen per ton of steel, and \$0.30 per ton in an openhearth using 700 to 800 cu.ft. per ton. This cost is certainly compensated for by the savings in labor, fuel, refractory and capital costs that result from use of oxygen.

The results obtained with the L-D process,

New Oxygen Converter on West Coast Pours Test Heat. (Courtesy Kaiser Steel Co.)

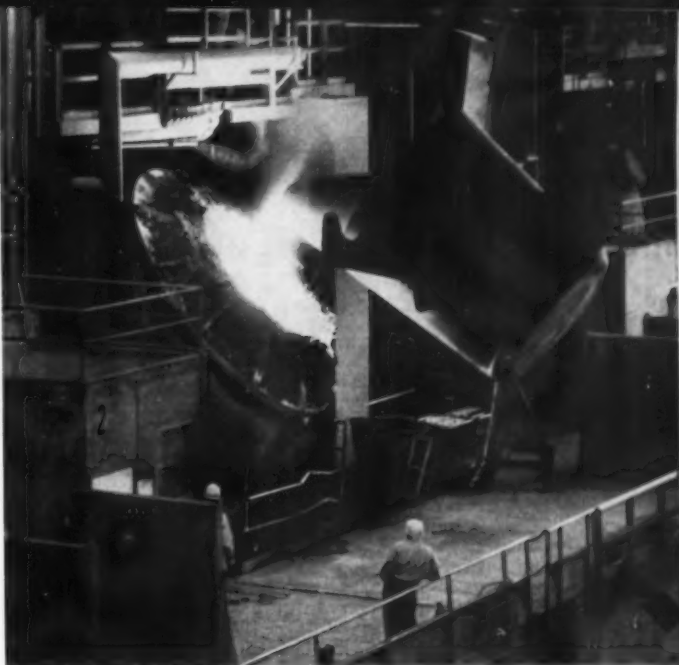


Fig. 1 - Oxygen Converter Being Charged With Molten Pig Iron. After subsequent charging with scrap and lime, a jet stream of oxygen refines the steel in less than 30 min. (Courtesy Kaiser Steel Co.)

since its first installation in Canada in 1954, have been spectacular. Steelmakers have been surprised to learn that almost any type of steel can be produced in this operation. Both high and low-carbon steel (ranging from 0.05 to 1.00% C) have been produced satisfactorily. Europeans even make 52100 and other alloy grades. In the United States, work has been confined to carbon steel grades, and nearly every heat has been applied as originally scheduled. In blowing, it has been possible to catch the carbon content on the way down at any level from 1.00 to 0.05%. This is usually done by blowing a constant oxygen for a definite time, or blowing to a lower carbon content and recarburizing to the desired carbon content before tapping.

One of the most surprising results of the L-D process has been the low phosphorus and sulphur contained in the heats. In general, amounts are definitely lower than can be reached in the openhearth furnace, and the resulting steel has been rolled much better than openhearth steel. For example, one company reports for a month's operation on the L-D converter an average of 0.01% P, 0.015% S, and 0.003% N.

Steel metallurgists probably have not realized the importance of this low sulphur content because they have had to live with 0.03 to 0.05% S from the average openhearth heats. The influence of sulphur in minute amounts in steel has

been emphasized by some other work, where sulphur content has been reduced to 0.007% in experimental heats. Compared to steel with 0.025 to 0.04% S, this low-sulphur material has great ductility at forging temperatures. On strip steel rolling, there is less edge cracking, and in seamless tube manufacture — a difficult piercing operation — seaminess is much lower.

As to theory, it is quite possible that the high temperatures reached during operation of the oxygen converter reduce some of the magnesium oxide, which makes up 50% of the lining. Magnesium has a very potent effect in the desulphurizing of iron and steel.

Converter Construction

Oxygen converters are built in sizes from 14 to 20 ft. O.D., and 25 to 35 ft. in height. The outside is usually made of plate 2 in. thick, while the inner lining consists of about 4 in. of magnesite brick. This is called the permanent lining and weighs 30 to 50 tons for a 50-ton vessel. The working lining usually consists of magnesia dolomite brick about 16 to 18 in. thick. Bonded with tar and weighing 100 to 150 tons, this lining generally contains 30 to 50% MgO. It wears out very rapidly as blowing proceeds. The life of an average lining is only about seven days, and anywhere from 180 to 250 heats may be made, depending upon the size of the vessel.

The working volume of a 50-ton vessel is 1150 cu.ft. when the lining is new, but this increases to about 1650 cu.ft. as the lining erodes. Obviously, the size of the hot metal charge increases as the lining wears. The ordinary plant has two or three converters, one of which is always being lined while the others may be in operation. It takes about five days to reline a vessel, so a plant with two converters would have one vessel operating and the other vessel being relined. At two different plants, the amount of refractory used per ton of steel is about 20 lb. Thus, refractory cost is much lower than in the openhearth.

The production of steel in these converters has been increased every year, and the end is not in sight. One plant with a 65-ton converter started out by producing 1400 tons per day. This has since increased to 3200 tons per day, which amounts to over a million tons per year for this converter. Average production rate per hour was 83.2 tons, which is at least two times as much as produced in the most modern openhearth furnace using oxygen.

The rate of production and the temperatures reached in an oxygen converter differ with the

rate of blowing oxygen, the amount of combustible impurities in the pig iron and the amount of cold scrap added as a coolant. Silicon is the greatest producer of heat, and about 25% scrap can be charged with about 1.00 to 1.25% Si. Oxygen blowing rates vary greatly, ranging from 3000 to 6500 cu.ft. per min. The temperature rises more rapidly as the rate of oxygen blowing increases. One company now blowing 6500 cu.ft. per min. is able to melt at least 30% scrap with a normal silicon content.

The oxygen must be about 99.5% pure, and the pressure about 150 psi. It is introduced through a long water cooled lance which has a water cooled copper casting on the lower end. This lance may be located at any level above the bath and retracted as desired for tilting the vessel. A projected new converter of 160 tons will probably have a blowing rate of 10,000 cu.ft. per min.

Growth of Oxygen Converter

In the last six years 31 plants have been built all over the world. These plants are distributed in the following countries:

COUNTRY	NO. OF PLANTS	NO. OF CONVERTERS
Austria	2	7
Belgium	2	4
Brazil	2	5
Canada	2	5
Finland	1	2
France	1	2
West Germany	3	5
India	1	3
Japan	5	10
Portugal	1	2
Spain	2	3
United States	4	12
U.S.S.R.	5	about 10

This gives one an idea of how this process has been accepted in most steelmaking countries.

Bottom-Blown Basic Converter

All of the bottom-blown vessels in the United States are acid lined and are now very little used except for screw stock and other specialties. Steel from these vessels is high in phosphorus (about 0.10%) and nitrogen (about 0.015%). There are no basic-lined converters in the United States.

The Western European countries such as Germany, Belgium, France and Luxemburg have made more than half their steel in basic converters which are bottom-blown with air. These vessels make a high-nitrogen steel, and specifica-

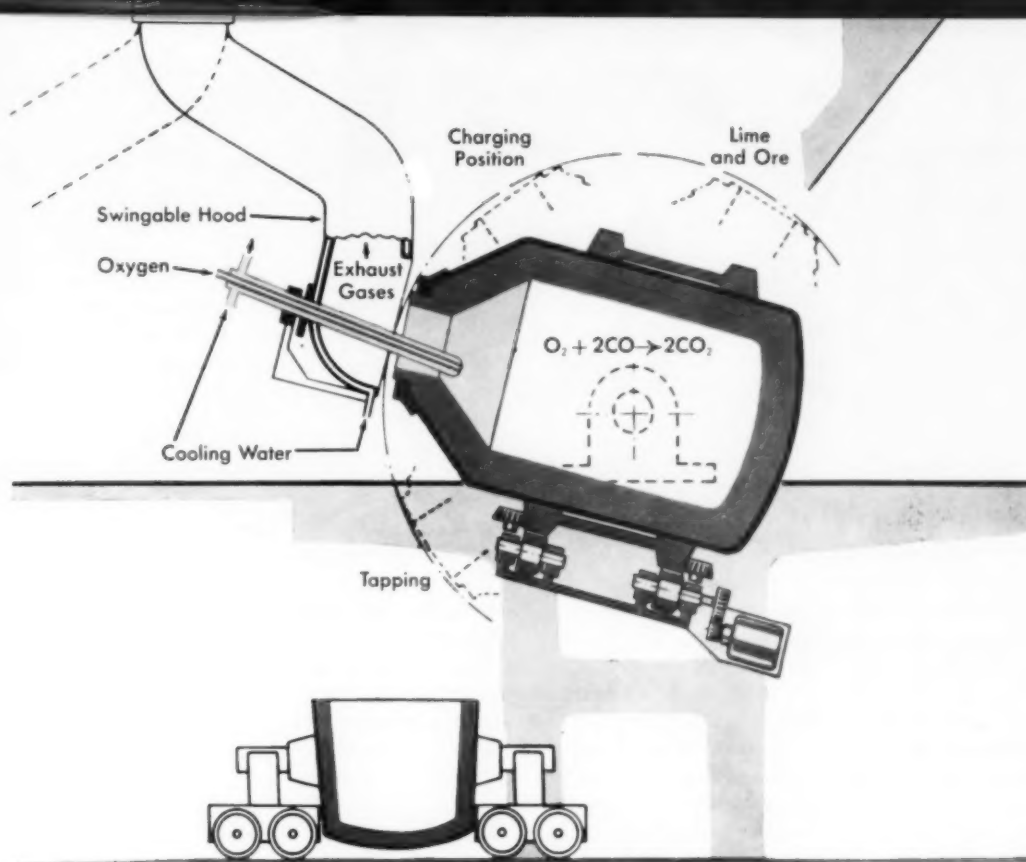


Fig. 2 — Diagram of Stora-Kaldo furnace in Operation at Domnarvret. The converter spins 10 to 30 times a minute while oxygen is being inserted. Reduction of impurities is very rapid. (Courtesy Dravo Corp.)

tions have become so rigid in respect to nitrogen that this method of making steel almost became obsolete. However, by using various amounts of oxygen, all of these plants have been revived and steel containing 0.008% N along with low phosphorus is now being successfully produced. This change was effected by blowing air enriched with up to 28% oxygen. Since the hot metal being blown does not take up nitrogen as long as the carbon is not over 1.0%, the nitrogen content does not increase. Final decarburizing and dephosphorizing are achieved by blowing with about 50% oxygen and 50% steam with no nitrogen in the blast. The Western Europeans claim that steel made in this way is comparable to openhearth steel. There are many variations of these practices, but they all have about the same results.

Another innovation in oxygen converters was developed by the Swedes, the so-called Kaldor process. In this method, a rotating converter inclined at an angle of about 17° (see Fig. 2 and 3) is rotated around the central axis at from 10 to 30 rpm. Oxygen is blown into the vessel much as it is in the upright oxygen blown converter, but the rotation of the vessel mixes the slag thoroughly, and phosphorus removal is most rapid. In this vessel, the Swedes have handled

hot metal with 0.15 to 2.0% P. When the phosphorus rises above 0.50%, the double slag process is necessary. Units up to 25 tons capacity have been put in operation in three different countries.

The use of oxygen for refining in the openhearth furnace is still in its infancy. As far as can be learned, only about two shops containing 20 furnaces are using oxygen in all the furnaces. There are over 900 openhearth furnaces in the United States, and nearly every steel plant is experimenting with the use of oxygen.

An openhearth furnace with a 50% hot metal and 50% scrap charge requires about 800 cu.ft. of oxygen per ton to refine the impurities out of the hot metal. This is about half of that used in the oxygen-blown converter. Some of the oxygen needed in the openhearth is supplied by oxidation of the scrap charge, oxygen contained in the furnace gases, and oxygen obtained from the limestone and ore charge. If the maximum amount of oxygen, 800 cu.ft. per ton, is used, an ore charge is not needed. Results obtained with oxygen blowing in the openhearth show

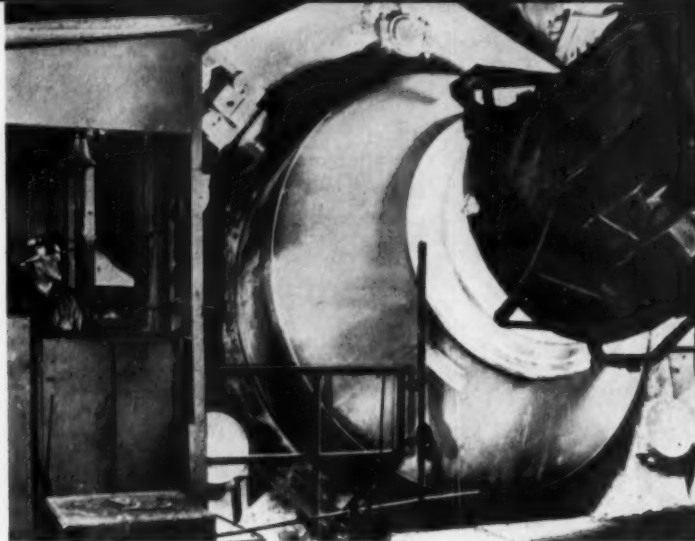


Fig. 3 — Stora-Kaldo Furnace in Action (Courtesy Dravo Corp.)

about 30% increase in tons per hour. Less lime, fuel and ore are used.

The plants visited were using anywhere from 130 cu.ft. to a maximum of 760 cu.ft. per ton, so the practice varies greatly, mainly due to a limited oxygen supply. If oxygen is used immediately after charging scrap, the bath temperature is raised and the rate of melting is increased. In a 300-ton furnace which produces about 30 tons of steel per hr., oxygen can increase production to about 40 tons per hr. In certain instances, oxygen-blown openhearth can produce 50 tons per hr., but the average in these plants using the maximum amount of oxygen was about 39 tons per hr.

In a large furnace, oxygen is usually introduced by a lance thrust vertically through the roof from both sides. Flow rates are about 40,000 to 50,000 cu.ft. per hr. Of course, oxygen cost must be balanced against the faster melting time, reduced ore and lime charges. Such calculations appear to favor the oxygen practice. If oxygen can increase openhearth production by 30%, the life of these furnaces can be greatly prolonged and capital investment costs for new production can be greatly reduced. Naturally, new capital for oxygen plants, and dust and fume control equipment would be needed.

The use of oxygen injection in openhearth furnaces has greatly changed their refractory requirements. Temperatures as high as 3100° F. are attained and the old silica roofs cannot stand these conditions. Furthermore, the large amount of iron fume also attacks silica refractories. As a result, practically all the openhearth furnaces using large amounts of oxygen have needed basic roofs. These have been standardized on magnesite chrome brick. In addition, the ends and slag pockets are usually lined with basic

bricks, because of the large amount of iron fume that develops.

Out of some 900 openhearth furnaces in the United States, there were about 103 with all-basic roofs in January 1959. This is an increase from only six basic roofs in 1956. The actual number of all-basic roofs is hard to estimate because some are now being built, while bricks have been ordered for others. Close to 200 all-basic furnaces are expected by 1960. Contrast this to Europe. There, basic furnaces have been used for 25 years, and most of the furnaces in Western Europe are now of all-basic construction. This is another indication of the conservatism of the American steel industry.

A tabulation of American furnaces in 1958 shows 730 silica roofs still in operation. These furnaces varied in size from 75 to 550 tons. In this tabulation, roof life is recorded; although it varies widely from 63 heats to more than 200 heats, the average life is about 125 heats for furnaces up to 175 tons and only 80 heats for furnaces of 250 tons capacity and over. On the other hand, the all-basic roof has shown a life varying from 150 heats on 500-ton furnaces to over 500 heats on furnaces smaller than 200 tons. The variation in roof life depends upon the rate of firing the furnace and the use of oxygen. Thus, it seems apparent at the present time that an all-basic roof costs two to three times as much as a silica roof and lasts three to four times as long. Apparently, in the long run, the all-basic roof is cheaper than the silica roof.

Both the oxygen-blown converter and the oxygen-blown openhearth furnaces generate a large amount of dust and fume. The red color of the smoke leaving the openhearth furnaces shows which ones are using oxygen. In the oxygen-blown converter, fumes are collected in a

hood and passed into a dust cleaning system. These are either washing devices to cool and wash the gases, or more usually Cottrell precipitators. The amount of dust collected from an oxygen converter varies between 60 and 180 lb. per ton of steel produced. Plants which are located in or near cities have to install these costly dust cleaning units to meet the various city ordinances which regulate smoke control.

Oxygen Enrichment of Combustion Flame

If the oxygen in the combustion air is increased from 21% to 25 or 28% by adding oxygen, the flame temperature and characteristics in the openhearth furnace are changed. More fuel can be burned per hour, the volume of the furnace gases decreases and the temperature rises. In this practice, usually about 300 to 600 cu.ft. of oxygen is used per ton of steel melted. This oxygen enrichment is usually done during the preliminary stages of the heat when the furnace is cold, and the large amount of cold scrap charge is slow to come up to temperature. By increasing flame temperatures during this period, scrap can be melted at a much faster rate, and hot metal can be added much earlier. Usually, oxygen enrichment is stopped after the heat is melted. The U.S.S.R. and Germany have done much more along this line than the United States. It is stated that, if the maximum amount of oxygen in the flame is 600 cu.ft. per ton of steel, about 1 hr. in heat time is saved.

Oxygen in Electric Furnace Melting

Electric furnace charges are essentially all scrap. Rarely is much pig iron, which contains large amounts of carbon and other impurities, added. Since the high heat of the electric arc melts scrap very rapidly, the use of oxygen on every heat is not general practice. In one instance, a shop which melted high-carbon rail steel scrap used oxygen for about 1 hr. to reduce the carbon content of the melt. This is done by passing a consumable lance through a wicket hole in the door. Oxygen is used in electric furnaces in melting stainless steel heats. Since about one million tons of stainless steel are melted a year, the amount of oxygen used is considerable. In melting stainless steel scrap which contains large amounts of carbon, it is necessary to reduce the carbon content of the bath to about 0.03 or 0.05%. To accomplish this, a controlled period at the highest temperature is required to reduce the carbon content without much loss in chromium. The amount of oxygen

consumed may be 300 to 600 cu.ft. per ton of steel, depending on desired carbon content.

Oxygen in the Blast Furnace

Blast furnaces blow a tremendous amount of wind, varying from 40,000 to 60,000 cu.ft. per min. To enrich such a blast by even a few percent would require an enormous amount of oxygen. If oxygen is added alone to the air, high hearth temperatures result. Faster melting rates then produce high-silicon irons. However, if steam and oxygen are added in about the same amount, hearth temperature can be regulated and a low-silicon iron can be produced. Emerick in his article cites experiments at Jones & Laughlin Steel Corp., where trial oxygen enrichment was varied from 0 to 2.5%. At the same time, the total moisture content of the blast was varied from 3 to 8 grains per cu.ft. With 1.5% enrichment and 5 grains of moisture per cu.ft., an increase in iron production resulted along with a small saving in coke consumption. When the air blast was increased to 23.5% oxygen with 7 grains of moisture per cu.ft., the iron production under these conditions was increased by 11.5% and the coke rate decreased 117 lb. per ton. There is certainly an attractive future for the addition of oxygen and steam to the blast.

It is evident that oxygen can accomplish spectacular increases in steel tonnages. The United States has been very laggard in promoting these applications while the Europeans have been aggressive and moved far ahead of us in the use of oxygen. There is a much greater percentage of all-basic openhearth furnaces in Germany and France, and the large production of converter steel using oxygen reflects their progress in this field. A recent article in *Iron and Coal Trades Review* in Great Britain takes the British steel industry to task for not developing the use of oxygen in their operations. Like the United States, most steel in England is made in basic openhearth furnaces, and openhearth operators have been much more backward in introducing oxygen practices in their plants.

There are no basic converters in the United States, mainly because our hot metal contains less than 0.50% P. However, there are instances where a basic-lined converter could be used with oxygen, and there may be some consideration of this old process in the United States. There will certainly be a number of new top-blown L-D converters installed in the United States, since these plants are making excellent steel at a lower cost than the present openhearth steel. ☛



Steelmaking on the Move

Ultrasonic Vibrations Refine Grain Size

*By D. H. LANE, J. W. CUNNINGHAM and W. A. TILLER**

Vibration during consumable-electrode melting refines ingot grain structure and prevents segregation. Secret of the technique is low-loss transmission of sound energy through the bottom of the mold. Several 12-in. diameter ingots have been made in which ultrasonic energy was applied. (C5h, 1-74; Fe-b)

ADD ULTRASONIC VIBRATION to consumable-electrode melting, and improvement in ingot grain size and homogenization promises a big advance in metals technology. This technique is being developed at Westinghouse. The process, while still in an early stage, has lots of potential with existing alloys as well as those which are not now forgeable because of ingot faults. In the future it will probably be applied to air melting operations in addition to consumable-electrode vacuum arc melting.

Two defects are fairly common in ingots—columnar grain growth and grain-boundary segregation. They often cause trouble during forging. Planes of weakness occur where columnar grains growing in different directions meet and preferred orientation leads to anisotropy in forgings. To eliminate columnar grains and segregation in cast ingots, the molten metal has been vibrated, inoculated, or stirred. None of these attempts has been entirely successful; the ingot structure usually changed to an intermediate one which still contained columnar grains with limited equiaxed area.

Rugged Power Source Required

Ultrasonic vibration of a large mass such as an ingot demands a power source which can operate at high energy levels. We selected a magnetostrictive transducer made from stacked

nickel laminations for preliminary work. It is rugged in design and can operate continuously at high power in converting electrical energy to sound energy. Best efficiency of our transducer was obtained in the frequency range of 5 to 60 kc.

Vibration of ingots during solidification has been tried before. Success was limited by the efficiency with which the vibrational energy can be transmitted to the ingot. In one technique, transducers are fastened to the walls and base of the mold. Much of the sound energy is dissipated at the mold-ingot interfaces as the cooling ingot shrinks from the mold walls. In another setup the mold functions as a transducer. This technique also proves inefficient because of poor mold-ingot contact and eddy-current losses at the mold and ingot surfaces. Both methods are successful in degassing liquid metals and in refining structures of small ingots; however, they do not effect similar improvements in large ingots.

In our method, the ultrasonic energy is transmitted to the ingot through a coupling bar which is brazed to the transducer and serves as the bot-

*Mr. Lane is an engineer in the materials engineering department, Mr. Cunningham is foreman of the metals processing laboratories, and Dr. Tiller is an advisory engineer at the Westinghouse Research Laboratories, Westinghouse Electric Corp., East Pittsburgh, Pa.

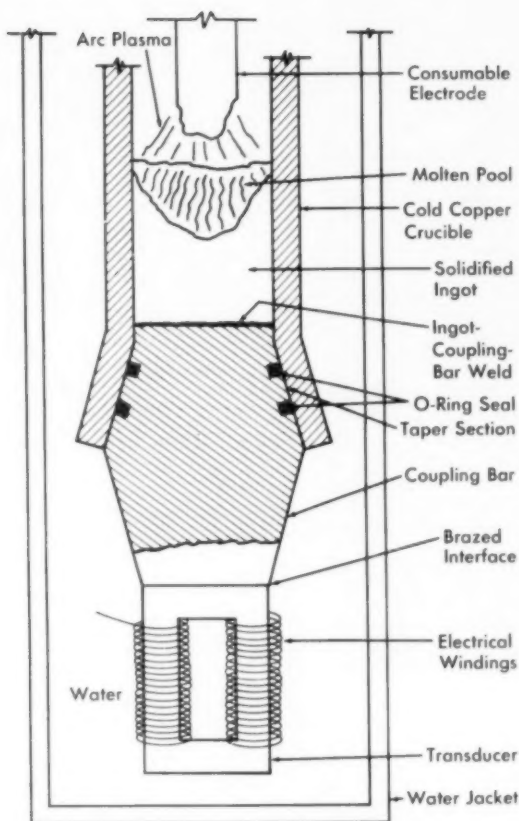


Fig. 1 — Apparatus for Consumable-Electrode Arc Melting With Ultrasonic Vibration. Transducer-coupling-bar assembly serves as the mold bottom

tom of the mold (Fig. 1). The ingot and bar are welded together at the start of the melting process. Thus a direct metallic path for the vibrational energy is provided from the transducer to the ingot. The efficiency of the technique is governed, however, by the area of the weld between the coupling bar and the ingot. Greater weld area means lower energy loss.

In early experiments, consumable electrodes of an austenitic, iron-base alloy (18 Mn, 5 Cr, 0.5 C) were arc melted in a 2½-in. diameter water cooled copper mold. A photograph of the transducer and coupling bar assembly used as the mold bottom is shown in Fig. 2. The transducer, a 5 × 2 × 2-in. stack of nickel laminations, was brazed to an iron coupling bar. Sound energy losses were minimized by isolating the transducer assembly from the mold with vacuum-seal O-rings.

Resonance Important

The initial arc was struck at very high current to melt a portion of the crucible base (the coupling bar). Amperage was then reduced to the lowest value which would produce a sound ingot, and the transducer was energized (400 w., 20 kc.). Adjusting the frequency to maintain maximum electrical power input to the transducer will maintain ingot vibration at a point near resonance, which is important for maximum efficiency. We measured the amplitude of the generated waves with a small piezo-electric transducer placed near the base of the trans-

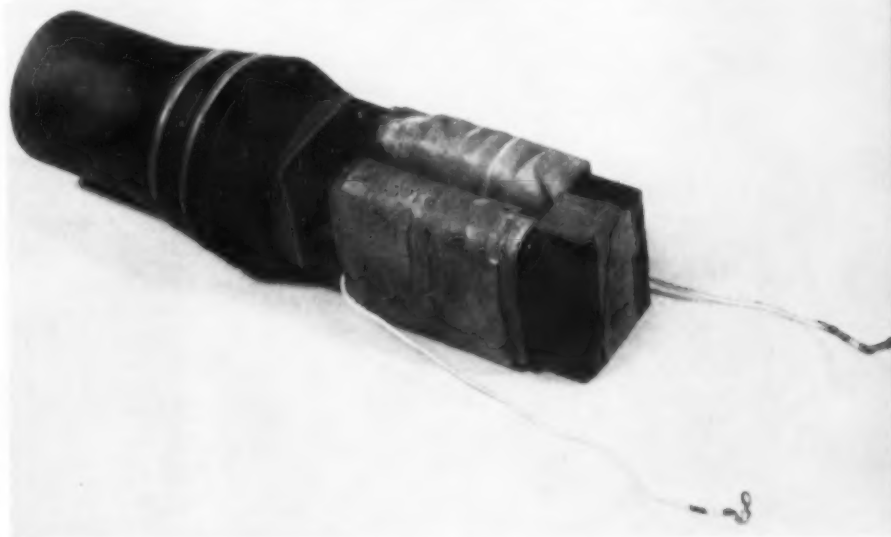


Fig. 2 — Transducer-Coupling-Bar Assembly. Transducer is made of stacked nickel laminations (0.008 in. thick) 5 × 2 × 2 in. O-rings on tapered section of coupling bar reduce energy losses to mold walls

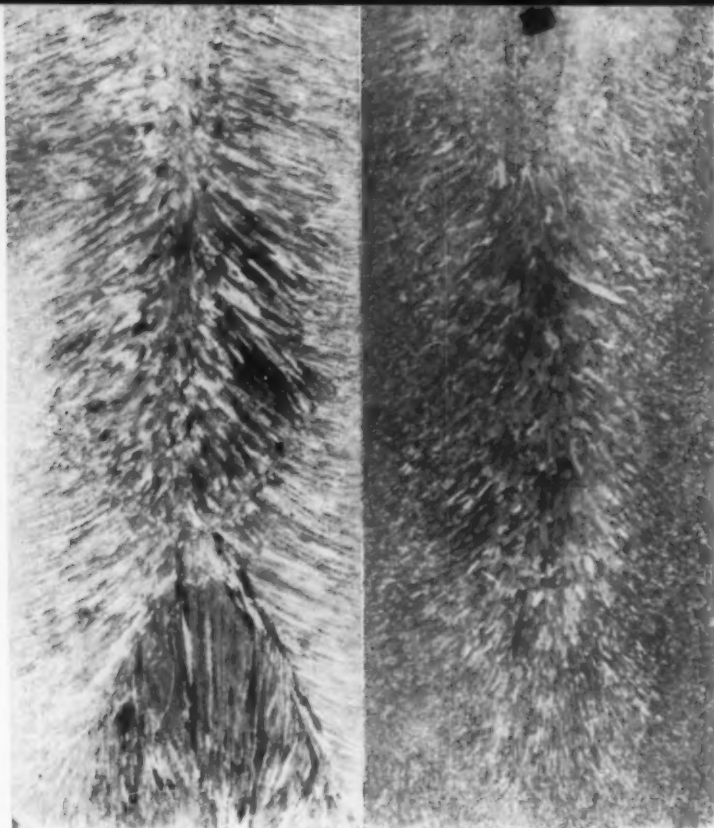


Fig. 3 — Macrostructures of an Austenitic Iron-Base Alloy Ingot, 2½ In. in Diameter, Made by Consumable-Electrode Vacuum-Arc Process. Left — Arc-cast ingot made without ultrasonic vibrations solidified as coarse structure of columnar grains. Right — Vibration has refined grain, reduced segregation, and eliminated planes of weakness in the ingot

ducer. The wave forms of the induced vibrations were then imposed on an oscilloscope and the frequency was varied to keep the amplitude of the wave at a maximum.

Ingot Structure Improved

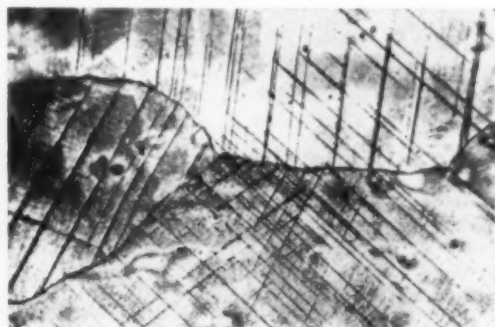
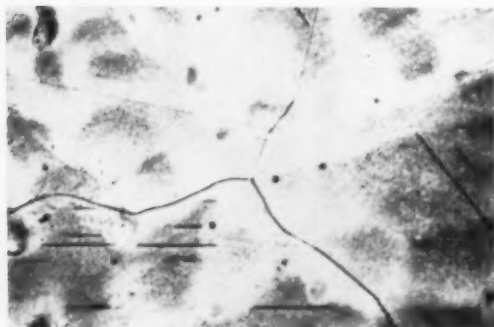
Macro-etched sections of the two ingots — one standard, the other vibrated — are shown in Fig. 3. Ultrasonic vibrations have eliminated the prominent planes of weakness and have suppressed columnar grain growth.

Examination of etched microstructures of the two ingots revealed a series of line markings

within the grains. Photomicrographs (Fig. 4) show that the lines are more prevalent in the vibrated ingot. Markings of this type are also observed in the same alloy after deformation and heat treatment. They are due to carbide precipitation on slip planes. In the vibrated ingot, the lines suggest that slip may be associated with the grain refinement which is attained.

The results of these experiments have been confirmed with other alloys of the same ingot size. More important — several 12-in. diameter ingots of other alloys have been arc cast by Westinghouse at its Blairsville, Pa., plant. ☉

Fig. 4 — Photomicrographs of As-Cast Structures. Left — Control ingot (no vibration). Right —



Carbide precipitation at slip planes is more extensive in vibrated ingot. Electrolytic polish, 250 ×



Steelmaking on the Move

Vacuum Degassing in Ladle ... a New Technique in Steelmaking

Hydrogen and other gases are removed from molten steel while it is in the ladle. By purging with helium while the vacuum is being drawn, hydrogen is reduced to less than 2 ppm. in about 15 min. This new technique permits steel from one heat to be poured into several ingots. (D9m, 1-73)

A NEW AND DIFFERENT method for vacuum degassing has been successfully devised by A. Finkl & Sons Co., Chicago.* Surprisingly, considering its newness, the concept is about as simple as it can be. A ladle containing air-melted molten steel is merely lowered into a large chamber which is then closed and evacuated. After about 15 min., the ladle of degassed steel is removed from the chamber and poured.

Since it may seem strange that such a simple version of vacuum degassing has not been applied before, some history might be in order. Actually, some Europeans tried to degas steel in ladles several years ago, but results were poor and the project abandoned. According to Tix (reporting in *Electric Furnace Steel Conference Proceedings*, Vol. 13, 1955, p. 70), "... ladle degassing has only a limited range in application. Owing to the ferrostatic pressure of the contents of the ladle, ...†

However, these investigators used aluminum-killed steel and mechanical pumps. They also tapped the full slag into the ladle, a technique that Finkl engineers found very detrimental.

Another question that might arise is, "Why should a forging producer be interested in vacuum degassing?" Well, large die block forgings

are a major item in Finkl's business. Being made of alloy steels, these die blocks are susceptible to ruptures when hydrogen is present. Like the producers of steel for large turbine rotors, Finkl became interested in vacuum degassing when results showed that the method could reduce hydrogen to levels at which rupturing from hydrogen flakes was no longer a problem.

They were offered several choices so far as technique was concerned. Aside from ladle degassing, there was available ladle-to-ladle degassing, and ladle-to-ingot degassing.

Since the company wanted to have equipment that could provide a wide variety of ingot sizes, they decided to try ladle degassing despite the adverse reports. They reasoned that, if the bugs could be worked out, the method would enable them to pour several different sizes of ingots from one heat.

*Some of the material in this article was presented by C. W. Finkl at the A.I.M.E. Electric Furnace Conference, Detroit, December 1958.

†What Mr. Tix means is that the steel on top weighs on the steel below to keep it from the vacuum. Thus, the steel at the bottom will not be completely degassed. Finkl overcomes this drawback by stirring the steel with helium injected under pressure at the bottom of the ladle.

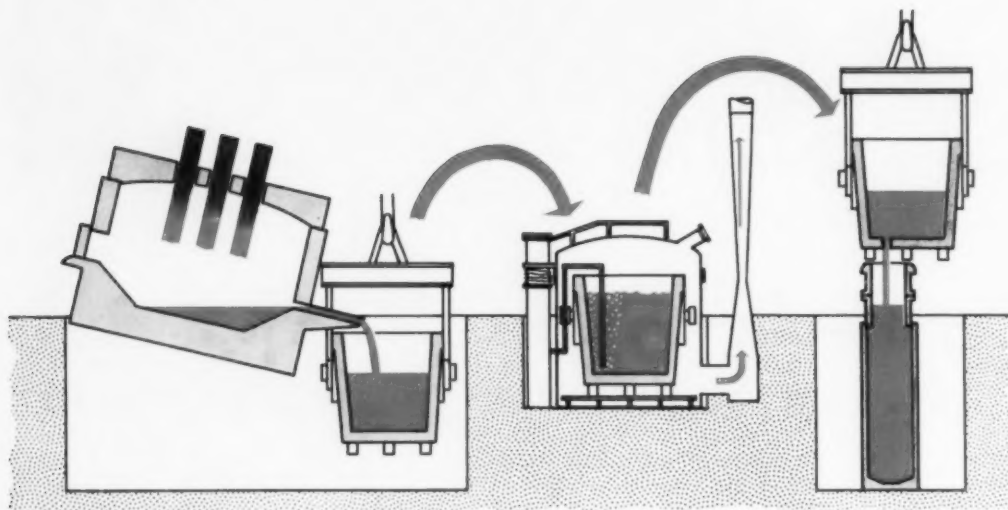


Fig. 1 — Diagram Showing Progress of Ladle From Electric Furnace to Degassing Tank to Pouring. A 35-ton heat can be degassed in about 15 min.

Equipment and Safety Precautions

A four-stage steam ejector was purchased that could pump 215 lb. per hr. of equivalent air at 500 microns or 0.5 mm. absolute pressure. This figures out to 71,165 cu.ft. per min. (cfm.) of air having a molecular weight of 29.* The ejectors were also designed to pump down 1000 cu.ft. to 500 microns in 5 min., the shortest possible tank evacuation time. (Speed is necessary because pumping can only be done while the ladle is in the tank, not before, as in stream degassing.) The first stage of the ejector was located as close to the tank as possible with the inlet of the first stage being bolted to the butterfly valve. This, in turn, is bolted to the outlet of the tank. The vacuum tank itself is 12 ft. 10 in. I.D. by 11 ft. 4 in. to the root of the dome. Total volume, including the circular segment of the dome, is 1592 cu.ft. This tank was planned to hold a 60-ton capacity ladle containing 37 tons of steel. (Finkl's heats average 35 tons.)

Steam for the ejectors is reduced from 135 to 100 psi. to insure constant pressure and quality. Cooling water is provided for the condensers from a cooling tower and 7000-gal. sump. It is interesting to note that when a cooling tower is used, enough steam is condensed to make up for the cooling tower's wind and evaporation losses. Hence no make-up water is required, but is provided anyway.

*This unit will also handle 385 lb. of equivalent air per hour at 1.22 mm., which is less than 70,000 cu.ft. of air per min. This shows how difficult it is to rate these things in cfm. Since most calculations of gas removal are by weight, perhaps it would be a good thing if people working with vacuum metallurgy would rate their units in lb. per hr. so a quick comparison of units can be made.

The control panel, which is the heart of the system, is laid out pictorially to aid operation. Electric interlocks make certain that ejectors can only be turned on in the proper sequence, and remain on only when the required steam, cooling water, control air, and electrical power are available. If the steam or water should fail or the third and fourth stages are turned off, the unit shuts down automatically. Shutdown is also controlled by a large red button on the control panel. If something should go wrong, this button completely shuts down the unit without further thought. A remote control station, adjacent to the vacuum tank, allows the operator to watch the boil through the window of the tank, while he operates the first and second stages of the steam ejector. He can shut down the unit and operate the device for removing the cover from the tank.

How the Unit Operates

The steel is made by the familiar double-slag practice with some exceptions. To control grain size, vanadium is used rather than aluminum. (Aluminum reduces the carbon monoxide boil while under vacuum.) About 30 to 40° F. of superheat is put into the bath prior to slag-off of the second slag. A second slag-off is needed since slag attacks refractory while under vacuum. Furthermore, the mass of slag on the bath reduces the boil, increases pump-down time, inhibits degassing, and gets the vacuum tank, ladle and first stage very dirty. The superheat and second slag-off take about 25 min. more furnace

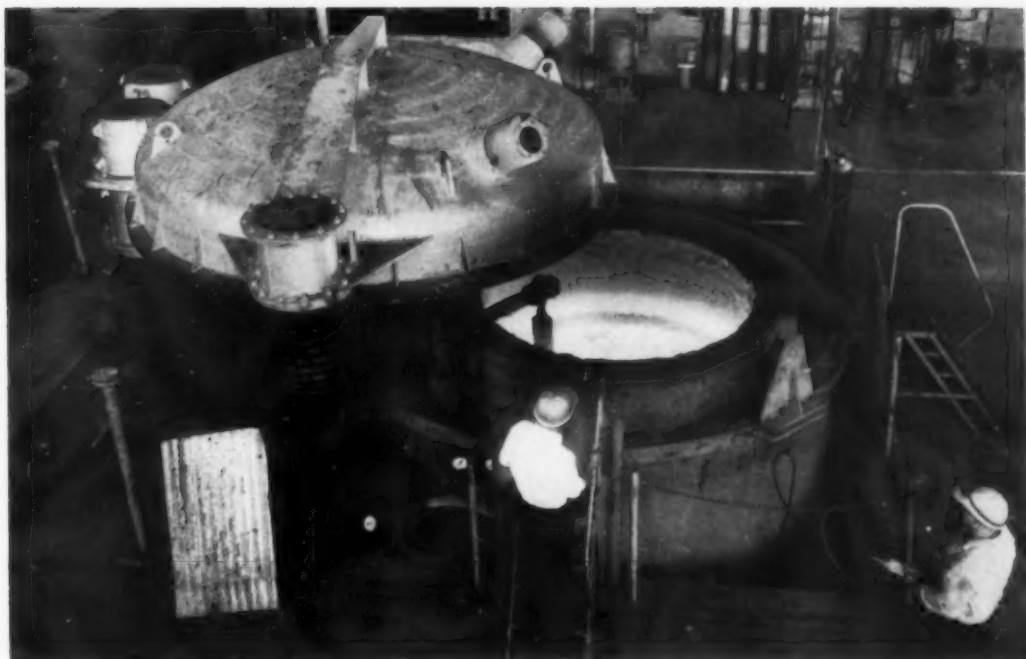


Fig. 2 — Degassed Steel Lying Quietly in Ladle. During degassing, the steel is purged by helium injected at the bottom through a pipe which serves as the stopper rod. The gas increases turbulence so that more steel is brought to the surface to be degassed

Fig. 3 — Steel Pouring From Ladle Into Mold. Note that stream is compact and does not spark; this indicates that very little gas is present



Table I—Mid-Radius Tests of Heat Treated Blooms

	X-1573	X-1607*	X-1612*	X-1618
Tensile strength	167,000 psi.	168,500 psi.	166,000 psi.	164,000 psi.
Yield strength	141,600	145,200	141,200	140,000
Elongation	10%	15.0%	15.8%	11.5%
Reduction in area	19.2	41.8	42.6	26.1
Hydrogen	3.5 ppm.	1.7 ppm.	1.6 ppm.	2.9 ppm.
Oxygen	66	42	34	68

*Degassed heats.

time. An additional two points of carbon and manganese are added to make up for a like amount that is lost under vacuum. Tapping is normal with ferrosilicon added to the furnace. Calcium-silicon and carbon are added to the ladle if needed. Transfer to the vacuum tank is as quick as possible. As soon as the ladle is in the tank, the cover is closed and pump-down is started. While the vacuum is being drawn, helium, under pressure, is forced into the bath through a pipe which serves as the stopper rod. This thoroughly stirs the molten steel. Since the purging tube is protected by the stopper rod refractory, it will not melt through. After 15 min. total tank time, the ladle is removed and poured. Figure 1 illustrates the process.

Temperature drop is critical since time and temperature control is partially responsible for the success of this process. Immersion thermocouple readings reveal 60° F. drop from the furnace before tap to the ladle. Immediately after tap, with very little slag on the ladle, temperature drops 3 to 7° per min., depending on the amount of slag and condition of the ladle during degassing and teeming.

The layman can readily see if a poured heat has been degassed or not. As Fig. 3 shows, a degassed heat, regardless of final gas analysis, has a very tight, compact stream, with no sparking. It looks like a solid red hot bar. Fluidity is definitely increased. Through a given nozzle, a degassed heat can be poured about 30 to 40° F. cooler in the same length of time as an undegassed heat. Current average total time from tap to pour is now slightly less than 30 min. This figure is being consistently reduced. The operators feel that if it can be lowered to 25 min. no superheat will be required. This will save 15 min. furnace time. No additional labor is required by this process. With proper planning, workers have consistently, day after day, degassed every heat made.

Though ladle life has shortened about 20%,

furnace life is relatively unchanged, in spite of the superheat. As for maintenance, every day the inside of the tank and the outside of the ladles are cleaned. Several hundred pounds of dirt come out of the first stage of the ejector every month. Other than this, the only maintenance is preventive.

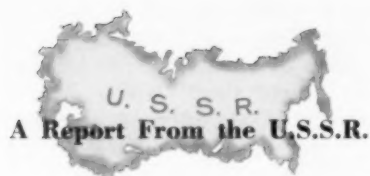
What Has Been Accomplished

Though most of the vacuum heats were run on Finkl FX (a chromium-nickel-molybdenum die block steel), all steels containing nickel are degassed by this process. To quote averages, in the last 100 heats hydrogen has been reduced from 4.3 to 1.75 ppm., and oxygen from 86 to 44.6 ppm. Tests on several degassed FX heats proved that flakes had been eliminated. Ingots were forged to 14 in. square by about 8 ft. long and laid on the floor of the forge shop to cool. After they were cool enough to be transported, they were taken to the inspection department for daily sonic readings. After five to seven months, no flakes have been found.

In other tests, four large blooms of FX steel were forged from 40-in. ingots. Two blooms were from degassed heats; the others came from two heats that were not degassed. After forging, these blooms were isothermally annealed, austenitized, water quenched, and tempered for 20 hr. at 1070° F.

The average of two mid-radius tests from each heat treated bloom is shown in Table I. Average increases of 43% and 86% were obtained for the elongation and reduction in area after degassing, while the tensile and yield strengths varied less than 4%.

To sum up, Finkl's new degassing method provides a serviceable product which is low in hydrogen and other gases. So far, they have not altered their cooling practices to take advantage of the lower tendency toward rupturing, but this project is definitely planned for the near future.



Radio-Isotopes and Soviet Steel

By ARTHUR B. TESMEN*

The Russians have evolved many methods for studying steelmaking processes with radio-isotopes. Blast furnace techniques which have been devised include ways to measure stock feeds, wear on furnace bottoms and charge levels.

In the refining process, much work has been done on dephosphorization, desulphurization, scrap melting, and slag formation.

Several experimental techniques are described. (D-general, 1-59)

ISOTOPES HAVE BEEN widely used in Russian metallurgy since about 1951. Figures of the U.S.S.R. Academy of Sciences show yearly savings of 1.5 billion rubles† in iron and steel-making alone. In addition, isotopes have been extremely useful in solving many difficult metallurgical problems. More than 30 research institutes, 20 iron and steel mills, and a large number of metalworking plants are using this tool. Several national conferences have been held, and more than 200 papers published on their use in metallurgical research, process regulation, and quality control in ferrous and nonferrous production, melting, casting and fabricating. This article will summarize Soviet uses of this method, and give typical applications in the metals field.

What Is a Radio-Isotope?

A radio-isotope is an unstable version of an element. Identical to the stable isotope in

atomic structure, it has a different atomic weight, and emits radiation — α and β particles and gamma rays — as it disintegrates. Radio-isotopes are used either as radiation sources or as tracers. Sources may be stationary (such as in radiographic flaw detection, thickness gaging of rolled sheet, strip and coatings, liquid level gaging and density measurements) or movable (to locate or follow a marked object, such as in liquid flow through piping, or radiographic quality control of a movable object).

Used as tracers, they emit specific identifying radiations while their chemical behavior is identical with that of their stable version. Materials "tagged" with the radioactive tracer atoms can be followed through complex processes and reactions. As such, they are used to study movements of material in systems which undergo complex physical and chemical changes. Some examples follow.

Blast Furnace Investigations

Investigating the blast furnace process with radioactive isotopes started at Novo-Tula Experimental Metallurgical Plant in 1951, and has been continued at Kuznetsk and Magnitogorsk

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†It is difficult to compare dollars with rubles. However, the official exchange rates are: foreign, 4 rubles to \$1; tourist, 10 rubles to \$1.

Metallurgical Combines, Dzerzhinsky, Azovstal, Stalinsk, Ilyich, and several other pig iron producing plants.

In studying movement of burden materials, radio-isotopes are introduced into a granule of ore, coke or lime. The tagged granule is then traced through the furnace by radiation counters strategically placed along the furnace shell, or by radioactivity measurements of pig iron or slag samples. At Novo-Tulsk P^{32} radio-isotope (as Fe_3P) and Fe^{59} (as an oxide) were added to the sinter before agglomeration. Baked sinter mass was broken into 2 to 3-in. pieces, and added to the furnace charge. Coke lumps were tagged with Fe^{59} and Ce^{141} isotopes by saturating in salts of these elements. An alternative method irradiates burden components in a nuclear reactor. This method is promising for tagging the ore particles, since it is difficult to tag the ore without affecting its mechanical properties.

Movement of the blast furnace materials is determined by two methods. In one scheme, the total time cycle — from charging of the stock into the top cone to its arrival at the smelting area and solution in the molten iron — can be measured. Tracer materials are introduced at the stock line at a definite interval before the iron is tapped, and the time cycle determined from the radioactivity measurements of the iron. This method does not require placement of radiation detectors and other special equipment, but it does not provide information on local rates of descent.

A more advanced method measures the rates of descent at eight furnace locations. Radio-active granules are introduced at the stock line, at a definite distance from the furnace center-line. To measure radiation, counters are placed at six furnace levels and two tuyeres.

As tagged ore, coke and lime travel through the furnace, their radioactivity is gradually registered at each level. Rate of travel is determined by measuring the time intervals between the maximum radiation intensities registered for each level, or by intensity increases from one level to another.

Radiation detectors can be placed outside of the shaft shell in the furnace lining or inside the furnace. The first version provides longest life and accessibility, but passage of radiation through the furnace lining greatly weakens its intensity. Granule radioactivity must be about 400 millicuries to increase the sensitivity of the measurements. Placement of radiation detectors in the furnace lining does not require

openings in the furnace walls (with the attendant maintenance problems), and produces good results with tracers of about 1 to 10-millicurie intensity. In the the third version, detector probes are introduced into the furnace for 5 to 20 min., and tracer intensity requirements are lower than in the preceding method.

In a study conducted at the Dzerzhinsky Iron and Steel Works, tagged granules simulating ore were introduced into the top cone of the furnace 4 in. from the wall. It was found that the ore and the coke first shift over to the furnace center-line and then move over to the furnace periphery as they move down. Sinter travel was faster at the center than at the edge. Lime moves more slowly in the lower part of the stack than at the top, and faster at the periphery bottom than at the center, but still overtakes the coke in its downward movement 10 to 30 min. after its descent from the stockline.

Similar experiments at the Azovstal Works determined that coke moves more slowly than the ore and sinter, and the sinter moves faster in the center of the furnace than near the walls. Novo-Tulsk investigations showed that the slow-moving ringlike area in the lower part of the shaft and in the bosh decreases the effective furnace volume by 10 to 15%.

Isotopes have been used to study mixing and movement of molten materials in the hearth of the furnace in an attempt to improve pig iron quality. They are introduced into the liquid pig and slag in the furnace hearth, through the furnace tuyeres, or by placement in the bottom brickwork. Radioactivity measurements of the slag and iron samples indicate the nature and rates of mixing of the molten materials in the furnace hearth.

Control of Brickwork Wear

A method for studying and controlling furnace bottom wear is shown in Fig. 1. It is intended to signal excessive brickwork wear, prevent breakdowns, and time furnace repairs. A 30-millicurie radiation source (1) is placed into the lower layer of brick in an ampule; a detector is placed into the water cooled tube (2); 0.5-millicurie radiation sources are placed at (3); and other detectors (4) are located in the water cooled probes connected to the controllers and recorders at a common pulpit. Changes in the radiation intensity reported by the detectors signal the destruction of the brickwork area under control.

This study determined that round furnace hearths which were water cooled at the bottom

periphery have longest life, and truncated cone-shaped hearths have the shortest life. It is expected that isotope control will be incorporated into the newly built furnace, and into the existing equipment whenever an opportunity is presented for alterations and repair.

The movement of gases in the stack was investigated by introducing radon, a radioactive inert gas, through the tuyeres with a special explosive device, and measuring the radioactivity of the waste gases. Gas velocity through a 45,000-cu.ft. furnace was determined to be 73 ft. per sec.

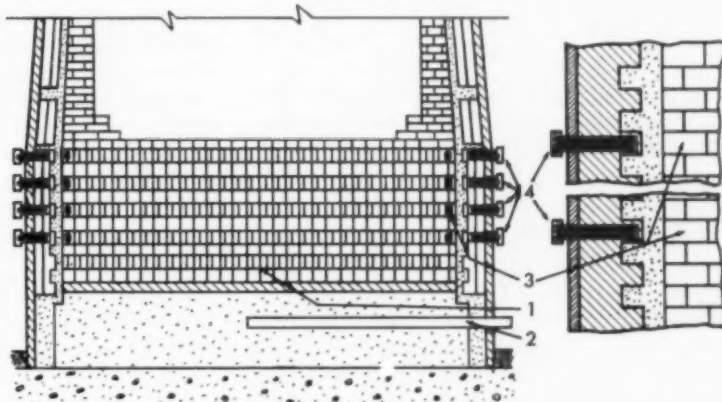
A device for controlling the fill level is being tested at one of the largest Soviet iron works.

consumption by automatic compensation for coke and sinter density variations.

Isotopes Aid Steelmaking Research

While Winkler and Chipman at Massachusetts Institute of Technology were the first to use P^{32} to study dephosphorization equilibria, Soviet researchers have been using radioactive isotopes to investigate dephosphorization and desulphurization, scrap melting, slag formation, and formation of impurities in openhearth and electric furnace steelmaking. By tagging the phosphorus and sulphur-containing ingredients with the P^{32} and S^{35} isotopes, distribution of these elements between the iron and slag and their

Fig. 1 - Investigating and Controlling Wear in a Blast Furnace Bottom. Points 1 and 3 show the location of radiation sources, and 2 and 4 indicate the sites of detectors



First, 200-millicurie Co^{60} sources are placed at the maximum charge level. The counters, wired to the control booth, are placed at four locations. Whenever the charge level falls below any of the radiation counters, it records the increased intensity, and a signal lamp lights up at the control pulpit. According to engineers of the Dzerzhinsky Works (where such a device has been in operation since May 1958), it equalizes the rate of material travel and effects more uniform furnace operation.

The same mill has also developed an automatic measuring device for density of sintered coke. Radiation from the source passes through a coke layer in a weighing funnel and is measured by a detector connected with a continuous recorder. Maximum radiation absorption indicated increased coke losses with the slag; as much as 11 to 13 tons of coke was lost through the slag notches. Since the coke in the hearth is about 2400 to 2600° F., considerable heat is lost from the furnace. Designers of this device expect to increase furnace production and decrease coke

transition and solution heat effects were determined. Tests made with Fe^{59} and S^{35} isotopes established that the transfer of sulphur between metal and slag is accompanied by flow of iron into the slag, and that it is essentially a diffusion process. Sulphur transfer is slowest in the slag; transfer of iron occurs through the slag-metal interface at faster rates.

Basic openhearth furnaces at the Azovstal Works in the south of Russia refine high-phosphorus raw material into steel and high-phosphorus slags. The latter are used as soil conditioners. A method of using residual slag from the previous heat to aid dephosphorization was evaluated by tracer studies. An ampule containing a 25-millicurie mixture of radioactive P^{32} and iron powder was placed into the slag blanket. The isotope distributes itself through the slag, and part of it enters the metal, the amount being proportional to the slag-metal distribution coefficient of phosphorus. Radioactivity measurements of the slag samples (taken at intervals throughout the heat cycle, and correlated with

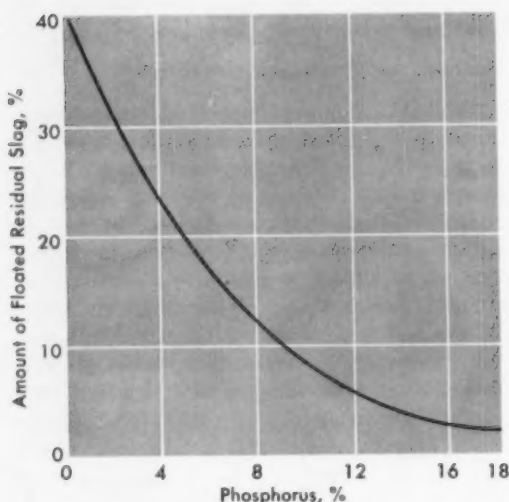


Fig. 2 — Relationship Between Amount of Residual Slag Floated During First Quarter of Melting and Phosphorus Content at End of Meltdown

the phosphorus content of refined steel) determined the amounts of residual slag which floated to the metal bath surface during the meltdown period. The results are shown in Fig. 2.

Scrap melting rate was determined by introducing iron or cobalt isotopes into the last ladle of liquid pig iron added to the furnace. Decreases in the radiation intensity of samples from the openhearth determined melting rate. The study indicated that melting rate rose with larger scrap surface, higher heat load and faster hot metal additions; it decreased as carbon oxidized.

The lime, ore and pig iron charging order was studied by tagging the lime with Ca^{45} , ore with P^{32} , and iron with Co^{60} . The dephosphorization rate was increased and the length of the meltdown period shortened by interspersing the lime layers with the ore, and by placing the lime deeper. In a 380-ton basic furnace, 70 to 80% of the scrap charge was dissolved in the liquid metal within 1 to 1½ hr. after the hot metal addition. Complete meltdown took 3 to 5 hr. more. A 45-lb. piece of ferrochromium placed in a 190-ton openhearth melted in 10 to 20 min.

Desulphurization of electric furnace transformer steel was "traced" by adding 150 millicuries of S^{35} to 1 ton of melt. Radioactivity measurements of the slag and metal samples (taken every 5 min.) indicated that intensive mixing of metal with the finishing slag and proper ferrosilicon additions aid desulphurization. However, the rate of pour into the ladle does not

affect the distribution of sulphur in slag and metal. The Russians found that thorough desulphurization could be achieved with soda-ash and calcium-aluminum slags.

It is well known that the rapid formation of a slag of correct composition is important for the successful melting of steel. To determine the conditions of slag formation in an openhearth furnace, layers of lime, pig and ore were tagged with Ca, Fe, and P isotopes. The nature and rate of slag formation and the effects of ore-to-lime distributions in the charge were determined from radiation intensity measurements.

In studies of alloy additions, it was found that Co^{60} added through the middle door of a 350-ton furnace was evenly distributed through the metal bath within 10 to 20 min. When the isotope was added through the side door of the furnace, mixing took 10, 45 and 55 min. in 24, 50 and 350-ton furnaces. Tests of W^{185} showed that large amounts of this metal vaporize from the metal bath in the presence of basic slags.

A modification of the tracer method — isotope dilution — was also used to study slag formation. This method determines amounts too small to be measured by chemical or spectroscopic methods, or which cannot be quantitatively separated from other materials in a system. A carefully measured amount of isotope is introduced into the slag or liquid metal in a definite ratio to the amount of "stable" atoms of the same element present. After the isotope is uniformly distributed, the change in this ratio, as determined by radioactivity measurements, will establish the unknown amount of element originally present. The Azovstal Works uses this method to determine the effects of special slags, oxygen and briquetting of charge materials.

Contamination by Nonmetallic Inclusions

Production of steel with a minimum of non-metallic inclusions depends largely upon the availability of data concerning the origin of these inclusions. Neither chemical analysis nor metallography can determine inclusion sources completely and accurately. Tagging the materials which come in contact with steel during its production makes it possible to trace each source of nonmetallic inclusions separately.

For example, Ca^{45} isotope (in the form of CaCo_3 and CaO) was placed into the refractory linings of the furnace, the ladle, and the pouring spout. Then, inclusions in steel ingots were electrolytically extracted and their source identified by radioactivity measurements. In a study

of contamination of ball bearing steels, 1.5 to 4.6% (depending on the type) of the inclusions were traced to the ladle lining and 0 to 0.7% to the lining of the pouring spout. Chamotte (36.4% $\text{Al}_2\text{O}_3 + \text{TiO}_2$), kaolin (44.4% $\text{Al}_2\text{O}_3 + \text{TiO}_2$), and clay (77.7% $\text{Al}_2\text{O}_3 + \text{TiO}_2$) contributed inclusions in descending order. While this work was based upon the use of Ca^{45} , isotopes of Al, Si, Mn and Mg are used for studies of inclusions originating from refractories, and during refining and deoxidization of steel.

Steel Pouring and Solidification

Solidification rates of rimmed and killed steels under various cooling conditions were studied by adding isotopes to the solidifying layers in the ingot mold. "Tagged" and "untagged" steel boundaries were detected later by contact radiography of templets cut from ingots. Relationships between the teeming rate, height of the ingot mold, and degree of solidification at various intervals after filling of the mold were established for ingots up to 6 tons.

Application of Ag^{110} isotope at the Chelya-

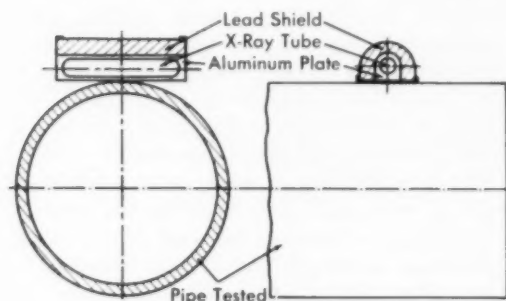


Fig. 3 - The X-Ray Tube as Used to Check Radioactivity of Pipe

binsk Pipe Works reduced the pilger-mill pipe reject rate from 44% to 15%. Rejections were due to laminations, blisters, eccentricity and blow-holes. Since laminations and blisters were the principal defects, it was suspected that they resulted from nonmetallic inclusions collecting under the oxidized outer crust of the ingot to form a lap on the ingot surface. This produced laminations and blisters when the ingot was rolled into pipe.

To check this theory and trace the defect origin, Ag^{110} was added to powdered coke as AgNO_3 , dried, and agglomerated into particles about 1 mm. in diameter (0.04 in.). The particles were added to the ingot crust immediately on its

formation. Radioactivity of the ingot surface, the intermediate pierced product, and the finished pipe was measured by Geiger-Mueller detectors, by the method shown in Fig. 3. Laps with porosity and inclusion concentrations, laminations and blisters were indicated by intensity maximums, and the mechanism of their formation determined.

To eliminate these laps, tar-soaked wooden hoops were placed into ingot molds under the hot tops; this reduced the reject rate to 15%.

Isotopes in Casting

Isotopes Co^{60} , Ir^{192} , Ta^{182} , Cs^{134} , Fe^{50} , S^{35} , P^{32} and Ca^{45} have been used to control cupola melting, study refractory wear, determine the mechanism of graphite formation in nodular iron, study the nature of solidification in continuous casting, and ascertain the distribution of impurities and inclusions in the castings.

In a cupola operation, it is important to control the level of the charge, since a low level may cause air to be sucked in through the charge opening. This will chill cupola gases and reduce furnace efficiency. One method for level control uses a 25-millicurie Co^{60} source. It is located on the cupola shell at the desired control level, and is connected to the signaling counter. When the burden has reached the desired level, the radiation intensity will decrease sharply. When its level falls below the desired minimum, the intensity increase is automatically relayed to the feed mechanism which returns the furnace load to the desired level.

Casting contamination caused by particles of the sand mold and core was studied with the Ca and P isotopes. Five millicuries of P^{32} (as H_3PO_4) was dissolved in water, neutralized, and mixed with the mold sand in a specified area. Since mold surfaces may wash into the casting (through impact of the metal stream, or rapid flow of molten metal, or crumbling due to the thermal gradient near the metal level), isotope tracers were placed to determine these effects, each separately. The casting was sectioned, and autoradiographs of each section then determined distribution of radioactive sand particles.

Rolling of Steel

As part of their drive toward automation, Soviet rolling mills have been adopting beta-gages to control thickness of steel sheet and strip. While the material travels between the radiation source and the detector, the amount of β -radiation that is absorbed gages the thick-

ness being measured. The instrument automatically compensates for changes in temperature, humidity, effect of dust particles, and other external factors.

Three types of gages have been designed. The first type uses Tl^{204} of 10 to 20 millicuries activity for gaging material in the 5 to 150-micron range; the second uses Ce^{144} (5 millicuries) or Sr^{90} for 50-micron to 1-mm. material; and the third uses Ir^{192} of 5 curies activity for sheet which is 2 to 10 mm. thick. Russian experience with the first two gages shows accuracies within $\pm 1.5\%$ of the measured thickness; they claim accuracy of ± 50 microns for the third type of gage, provided the material is stationary.

The Russians are working on more rapid-acting and accurate gages to meet the demands of increased rolling speed and stricter tolerances, using scintillation counters with periodic correction during intervals between the measurements.

Continuous measurements of tin and zinc coatings are made with back reflection type gages, which use ionization chambers to measure Tl^{204} radiation back-scattered from the coating. Using 70 millicuries of this isotope assures accuracy of ± 0.15 micron for tin coatings and ± 2 microns for zinc coatings in the 0.002 to 1-mm. thickness range.


Metallurgical Research

Adding tracers to the melt, or bombarding it in a reactor (with subsequent measurements of radioactivity or autoradiographic techniques), makes it possible to determine the distribution of elements in a comparatively small area of an alloy. These methods have been extensively used by Soviet researchers to ascertain the manner in which elements are distributed in alloys. Other studies have determined atomic mobilities in solid solutions and the influence of alloying elements on the properties of alloys. The mobility of the solvent atoms is one of the main factors affecting structural changes in solid solutions, and their behavior under stress and at elevated temperatures. Addition of alloying elements leads to changes in atomic interactions, and hence in the properties of alloys.

Artificial radioactive isotopes were used to measure directly the diffusion coefficients of the alloy base elements. Calculation of the diffusion coefficient requires that the concentration change and the depth of the diffusion layer be measured at the same time. The work is precise, and radio-isotopes help by allowing minute concentrations of the diffusing substance to be

determined. The substance to be investigated is mixed with the isotope and deposited on the specimen surface from which it penetrates into the layer underneath. Thin layers are then mechanically removed from the specimens and their intensities measured. Electropolishing to remove still thinner layers is even more accurate. The autoradiographic method is based on the effect of radiation upon a photographic emulsion. To obtain distribution of elements in an alloy, a thin section of an alloy containing a radioactive substance is prepared. Contact with the photographic plate emulsion then produces a mirror image (after development) of the radioactive distribution. The method is extremely sensitive. For example, enrichment of grain boundaries of Pb-Sb alloy by radioactive Pb was indicated when 1 atom of Pb isotope to 10^{10} atoms of stable Pb was present. Autoradiographic techniques have been used to study the distribution of elements and impurities in iron and nickel alloys; this work has indicated a marked chemical inhomogeneity within single phases and structural elements. Autoradiographs of several elements in a nickel alloy have indicated that elements such as molybdenum, columbium, zirconium and titanium and impurities such as tin, sulphur, phosphorus, antimony and cerium are present at the grain boundaries and in the interdendritic regions, while iron and tungsten are found within the grains.

Distribution study of tungsten in nickel showed that for 3.2% average content of tungsten in nickel, some regions are impoverished to 2.3% W and others enriched to 4.8% W. Nonuniform distribution of the alloying elements was observed within single grains and separate dendrites. Autoradiographs are also useful in determining concentrations of such impurities as sulphur, phosphorus, lead, tin and antimony at the grain boundaries of iron and nickel alloys.

In addition to these extensive uses in steel research, the Russians have used radio-isotopes in welding research. They have also determined behavior of liquid titanium in graphite crucibles to select correct thermal and time cycles for titanium melting, used Co^{60} to evaluate the homogeneity of the mechanical mixture of iron powders, and studied wear of motor parts and machine tools. While space is lacking to list all of the many uses that the Soviets have made of radioactive isotopes, this brief outline shows that they have made great advances. Their experience and ability in isotope use is fully comparable to ours. 

Bigger, Better and Sounder Forgings—Part II

By ERNEST E. THUM*

Service performance is simulated by a bored and notched 2-ft. disk spun to destruction. Tough steel should have transition temperature of 100° F. or lower, as judged by Charpy tests having 50% or more fibrous fracture. Vacuum casting of highly refined basic electric steel has greatly improved the soundness of forging ingots. (Q26s; AY, 4-51)

LAST MONTH was published the first part of a review of quite recent studies of large forgings, leading to the production of bigger and sounder rotors for large steam turbines and electric generators. Since the troubles with this class of heavy equipment arose, more has been learned about ultrasonic inspection, and its limitations have been much more sharply defined. Basic electric steel, vacuum cast, has also provided cleaner ingots with lower sulphur, phosphorus, oxygen and hydrogen, giving forgings of tougher steel, less liable to initiate cracks at the inevitable localized stress-raisers and to resist their propagation, once started.

This final section will describe the specialized tests devised to simulate the service performance of large rotating masses of metal, and the modifications in manufacturing practices which have resulted from the information gained thereby.

It was long assumed that stresses in an operating rotor can be simulated by spinning a disk made of the same material (Fig. 6†). Under this assumption the average bursting strength (ABS) would be the centrifugal stress L_c divided by the area on the diameter; that is

$$ABS = L_c \div A = L_c \div Dt$$

The old theory of design was that this should equal the ultimate tensile strength (UTS) of the metal as determined by the standard 0.505-in. test piece — that is, that $ABS = UTS$, and a factor of safety of four was commonly used by the designers.

This was a satisfactory concept until 1953 when certain rotors failed under working conditions such that the actual average bursting

strength of the massive forging was one third to one quarter of the ultimate tensile strength! Furthermore, when the fragments were sampled, they proved to have the expected and specified tensile properties — normal tensile strength, elastic limit, reduction of area and elongation. The fly in the ointment here was that the fracture surfaces of the small test pieces were free from serious stress-raisers, while disastrous rotor breaks would start at some defect such as a flake, a machined notch or a group of inclusions.

Now, it is not enough to blame the obvious. For example, Pittsburg generator No. 1 split in two, the break starting from an accumulation of slag particles near the axis. Pittsburg generator No. 3, built to the same specifications at the same time and with substantially equivalent operational history, was removed intact for study and a similar accumulation of slag particles was trepanned from its axis. Rotor No. 1 broke and Rotor No. 2 didn't! Furthermore, when small disks like Fig. 6 from each of them were spun to destruction both gave the same result, namely $ABS = UTS$ or $ABS \div UTS = 1.00$. Evidently

*Editor-in-Chief, *Metal Progress*. The observations contained herein — his own — were principally inspired by a visit with Dolph G. Ebeling, head of metallurgy, and other members of the technical staff of the Large Steam Turbine-Generator Department of the General Electric Co., Schenectady, N. Y. Supplementary ideas were gathered at the First National Metals Engineering Conference of the American Society of Mechanical Engineers, held in Albany, N. Y., April 29 to May 1, 1950.

†Figures are numbered consecutively from the previous installment.

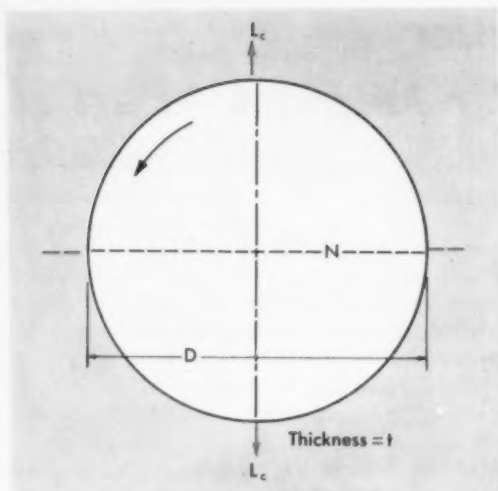


Fig. 6—Sketch of Small Test Disk, Supposed to Simulate Action of Metal in Large Rotors When Spun Rapidly

some other means would have to be found to distinguish a safe rotor from a dangerous one.

This has been achieved by bringing in the criteria of size of the piece and the character of the fracture. In taking a look at the first one, size, the engineers at General Electric made a series of notched bars of various sizes which were broken in bending in a large testing machine. The bars were similar in shape to the standard Charpy V-notch impact specimen, but they ranged in size up to a 9×9 -in. cross section. The notch depth was maintained at 20% of the gross depth and the notch radii were usually maintained constant at 0.005 in. Results of these

tests indicated the influence of restraint at the base of the notch—the larger the test piece the smaller the chance of preliminary ductile flow in directions normal to the principal stress.

In some steels, the load-carrying capacities of these notched beams were seriously reduced as the size of the specimens was increased. This is shown in Fig. 7, where the nominal bending stress at the root of the notch is plotted against the width (and depth) of the specimens. The curves contrast the results on specimens cut from fragments of the "Arizona" rotor and from another forging of similar chemical composition. It will be noted that these tests were successful in reproducing the catastrophic fracture of steel from one of the defective rotors at very low stress levels, comparable with those that existed at the time of the rotor failure.

Character of Fracture—A notable difference between the steels which suffered a large loss in bending strength with increasing size and those which did not was in their ductile-to-brittle transition temperature as determined in the standardized Charpy impact test. It has long been known that the energy absorbed on impact test by any ferritic steel depends on the temperature of the test piece. The metal is "tough" at high temperature and "brittle" at low. Somewhere in between is a "transition" temperature—frequently located at where the Charpy test piece absorbs 15 ft-lb. of energy. The general situation is shown in the solid line of Fig. 8.

However, the men at Schenectady place much emphasis on the *appearance* of the fracture; the proportion of cleavage (transcrystalline) fracture in the break is noted and plotted and the remainder of the area is fibrous or intercrystalline. By

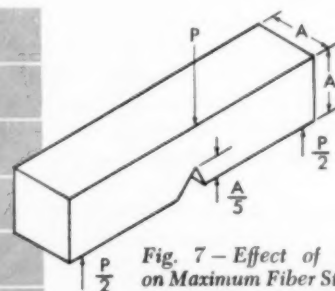
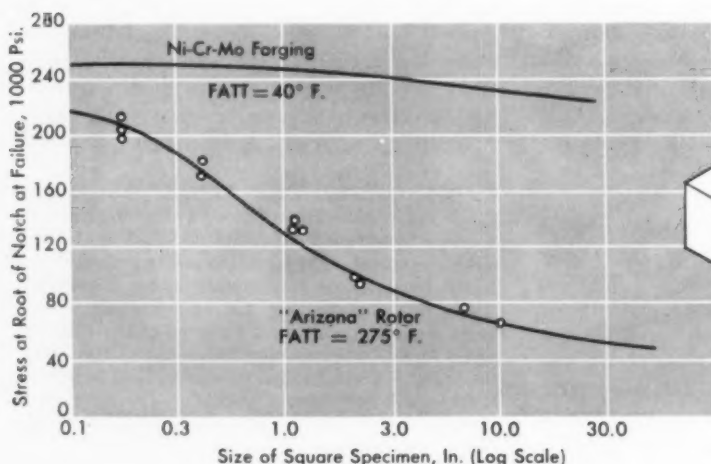
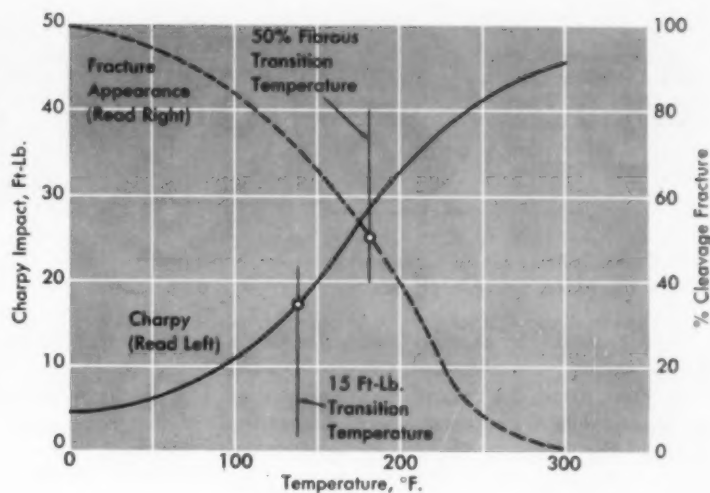


Fig. 7—Effect of Size on Maximum Fiber Stress at Fracture of Notched Ni-Cr-Mo Bars Made From Broken "Arizona" Forging, and Test Bars From Another Large Forging of Much Lower Transition Temperature

Fig. 8—Influence of Temperature on Energy Absorption and Fracture Appearance of Ni-Mo-V Steel From Broken Pittsburgh Rotor. The "Fracture Appearance Transition Temperature" (FATT) of this steel is about 175° F.



this criterion the transition temperature is where the fracture is half fibrous and half cleavage. As also shown in Fig. 8, the metal in fragments from the Pittsburgh No. 1 rotor had a fracture appearance transition temperature (FATT) of 175° F.

Disk Tests—Such experiments led the engineers at Schenectady to go one step further in their attempts to develop "model" tests that would provide reliable indications of steel performance in large rotating bodies. For this they turned to tests of spinning disks. Their first tests were conducted in a relatively small spin pit which could burst disks approximately 10 in. diameter and ½ in. thick. Some of these results are summarized in Fig. 9 and they show that the introduction of stress concentrations into spinning disks could lower the bursting strength and this is particularly dangerous if the steel were not ductile. The sketch summarizes results on "tough" metal—FATT 40° F.—and of "brittle" metal from burst rotors—FATT 275° or higher. Sensitivity (S) is appraised by dividing the average bursting stress of the disk by the tensile strength of a 0.505-in. tension specimen—that is, $S = ABS \div TS$. It is to be noted that a 4-in. center hole, simulating the axial bore in the rotor, does not change S for the ductile material even though such a hole is a stress-raiser, doubling the stress at its perimeter. Seemingly the ductile steel could deform plastically enough to prevent any crack from starting at such a place. The brittle metal could not; note that $S = 0.78$ if the disk was merely centerbored.

The third sketch shows more dangerous conditions when a center bore is supplemented by 45° notches 1 in. deep in the outer rim. S for ductile

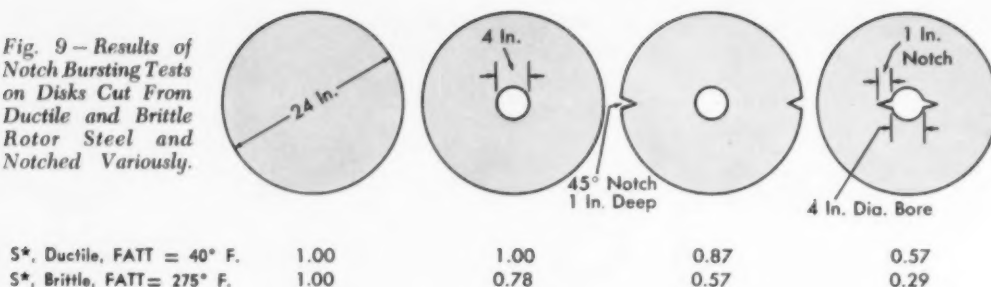
metal is then 0.87 and 0.57 for brittle. However, the investigators hit the jackpot when the notch was put into the *inner* bore—simulating the presence of axial bursts or inclusions not removed even by trepanning. S for the brittle material then comes out to be 0.29, right where the rotors actually broke in service—0.25 to 0.33 of their tensile strength.

These results clearly demonstrated the effect of stress concentrations and the conditions of restraint on the fracture behavior of these rotating bodies. Clearly, it was important to extend these studies to thicker disks and cylinders in order to minimize the plastic flow that might take place in these relatively thin disks. For this purpose, the notch bursting tests are now performed in heavily armored pits. Normally the disks are tested at 70° F., but since it takes such a short time and the large disks change temperature slowly, tests can be made at any desired temperature merely by preheating or cooling the disks immediately before closing the test-rig. Another heated pit conducts long-time spin-rupture tests at elevated temperatures.

As regards the effects of geometric factors, it has been found that the bursting strength of thick disks is somewhat lower than thin disks, but above 3 in. thick there is little further reduction. Therefore, the Schenectady engineers have standardized on the following design for the spin-test piece: 24 in. O.D., 4 in. I.D., 3 in. thick, with two longitudinal internal notches in the bore 1 in. deep with a 0.005-in. root radius.

Results using this specimen are summarized in Fig. 10, which correlates ABS (corrected for variations in tensile fracture stress which is

Fig. 9—Results of Notch Bursting Tests on Disks Cut From Ductile and Brittle Rotor Steel and Notched Variously.



affected primarily by ductility) with the FATT as determined in a standard Charpy V-notch impact test. Both FATT and tensile properties are measured in a transverse direction near the center of the forging. This figure contains the experimental data for a wide variety of alloy compositions and heat treatments and it will be noted, first, that the correlation is quite good for all alloys, and second, that the FATT exerts a powerful effect on the bursting behavior of disks. With high transition temperatures, the bursting strengths are just in the range of those rotors that broke in service, whereas tougher materials will develop bursting strengths two or three times as great.

This extensive, and very expensive, testing program thus demonstrated that the cause of the rotor failures in service was the combination of some type of sharp stress concentration (flakes, machined notches, or inclusions) and a steel with a low capacity for plastic flow under conditions of high restraint.

A final verification of the reliability of this

*S = ratio of average tangential stress at fracture to tensile strength of unnotched 0.505-in. round bars.

disk test, proving that it is the moderate-sized test which can be performed in the laboratory and which does represent actual service conditions, comes from work done on four rotors removed from service. For this purpose, the General Electric Co. has erected near the village of Malta an old and greatly reinforced armature casing made of welded and ribbed plate, within which sections of full-sized rotors can be spun to destruction. (This is really expensive business!) To date, four such retired rotors have been tested, and compared with tests on 24-in. disks cut from the rotors themselves.

Rotor A had a high fracture appearance transition temperature (FATT = 240° F.). It had originally been center bored and before test the center bore was notched end to end in the same way as the test disks. Small disks said it would burst at about 8% overspeed. It did.

Rotor B had a low FATT (80° F.). It also was internally notched, end to end. A test disk said it would burst at 50% overspeed. It was run 3 min. at 60% overspeed without trouble, during which the forging carried about 2.5 times the design stress.

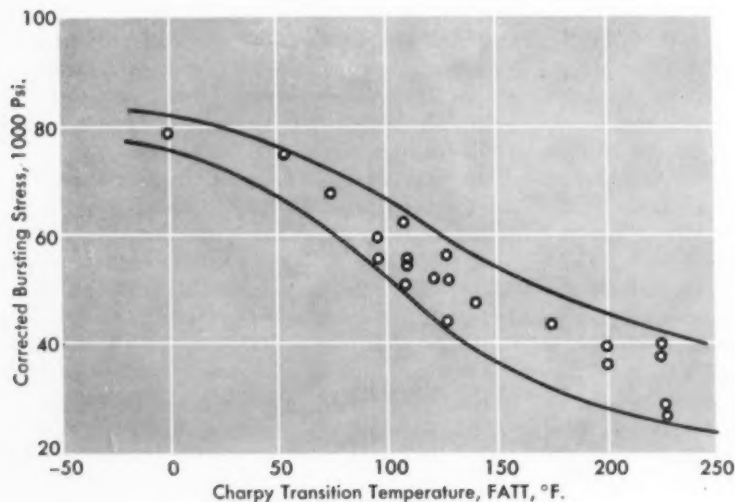
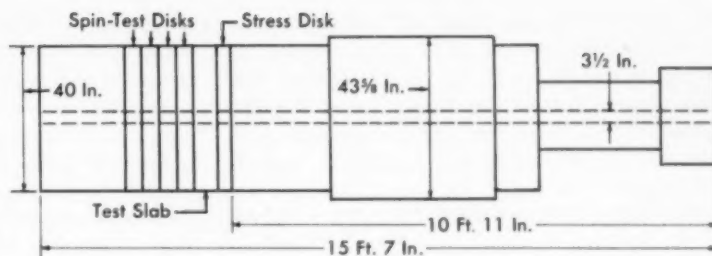


Fig. 10—Corrected Bursting Stress of Large Forgings Versus Fracture Appearance Transition Temperature as Determined From Standard Charpy Specimens. Vertical ordinate is the observed average bursting stress $\times 140,000 \div$ true fracture strength (which is a function of the strength and reduction of area in the standard tensile test)

Fig. 11 — Outline Drawing of 25-Ton Rotor Forging With Prolongation for Test Disks and Other Specimens



Rotor C had a rather high FATT (200° F.). It had originally been bored and was not notched before testing. Disks said the danger point was 50% overspeed if no severe stress concentrations were present. None were observed in usual inspection and it safely withstood the proof test given to Rotor B.

Rotor D was solid (unbored) and had medium FATT (180° F.). It was tested as received. Disks again said the danger point was above 50% overspeed. It was run up to 56% overspeed safely and the test stopped.

Improvements in Forgings

Further correlation of low FATT with high bursting strength has been derived from experiments with more than 50 disks cut from 36 forgings delivered with extra material for tests (such as shown in Fig. 11), from old forgings rejected for various reasons, from the three rotors which broke in service, and from suspicious equipment recently withdrawn from operation. Cooperating in this program, steel plants have varied their steelmaking and forging methods as laboratory work indicates desirable modifications. One forging has been bought in England and three in Germany to investigate the properties of metal thought by foreign metallurgists to be optimum in composition and treatment. Periodic conferences are held with American steelmakers. Interchange of information among the electrical and steel industry is through a Task Group on Brittle Fracture* of the A.S.T.M.

Obviously such tests as indicated above are expensive so they must be carefully planned to give the maximum information. As noted above, Fig. 10 shows the relationship of bursting strength of bore-notched disks with their fracture appearance transition temperatures (FATT)

*A. O. Schaefer, chairman, president Pencoyle Steel & Forge Corp., Philadelphia, and past-president American Society for Metals. This task group is also sponsoring an independent investigation of temper brittleness — the tendency of certain alloy steels to lose toughness if slowly cooled from desirable tempering temperatures.

as observed in a series of Charpy tests such as in Fig. 8. Other correlations show that FATT (Charpy) is apparently related to the transformation temperature; it is desirable that the austenite in these large forgings, which cannot be quenched hardened to any depth, should transform on air cooling at their natural rate of about 100° F. per hr. into low-temperature bainite rather than high-temperature bainite. Furthermore, the austenitizing anneal in the forge plant should be at the lowest practicable temperature to prevent large grain growth and a coarsened structure in the final rotor. To achieve these desirable microstructures, much study has been given to the effects of small chromium additions to the conventional Ni-Mo-V rotor steels to increase their hardenability and still avoid that old bugbear, temper brittleness. Preliminary results are encouraging; improved alloys will be necessary before sizes and speeds of new rotating equipment can be increased.

One of the most important achievements, so far, has been a modification of the "standard" 0.30 C, 2.75 Ni, 0.5 Mo, 0.1 V analysis which has proved to be a pretty satisfactory compromise for the various requirements of the different parts of the machine, briefly stated:

For the high-pressure stage of the turbine — high-temperature strength and ductility, as well as dimensional stability (creep resistance) up to operating temperatures of 1000° F.

For the low-pressure stage where centrifugal stresses are high due to the long blades attached — high strength and toughness at 300° F.

For the intermediate stage, properties should be intermediate.

For the generator rotor, strength and toughness at moderate temperatures are needed and to this must be added good magnetic permeability. The latter requirement also indicates that the forging should not be center-bored.

To meet these requirements, the much-used Ni-Mo-V combination has good magnetic permeability, is free from temper embrittlement, is stable dimensionally and metallurgically under

the operating temperatures, and has small tendency toward segregation of alloy content in center or top of ingot. In recent forgings the molybdenum content has been lowered slightly so the final microstructure can contain some proeutectoid ferrite, a smaller grain size, and a much lower FATT.

This alloy does have some drawbacks: It has a high tendency to absorb hydrogen, but this has been corrected by vacuum pouring. It is not as strong as desired; said in another way, a preferred alloy should have a higher hardenability on slow cooling. Some important changes have been made in chemical analysis. As already indicated, steelmaking practice has gone over exclusively to basic electric furnaces, to drive sulphur and phosphorus down. Further, since glassy manganese silicate inclusions have been highly suspect in the operational failures, manganese has been reduced from the old 0.75 to 0.50%. As a consequence of these new practices, the sonic quality of forgings has been greatly improved in the last few years. Not only are the number of rotors rejected for sonic indications reduced to a vanishing point, but the average quality has been raised significantly.

One other disadvantage of the Ni-Mo-V steel may be mentioned: It can have a high transition temperature. In this respect it appears that composition and heat treatment are of more importance than minor variations in steelmaking and forging techniques; prime factors are lower temperature for transformation of austenite into bainite (achieved by reducing molybdenum to 0.30%) and a lower austenitizing temperature during the final heat treatment.

Toughness has been improved significantly. Old specifications said nothing about transition temperature (FATT), and in the Arizona rotor it was 275° F. Since 1957 it has been specified at 175° max. and it is intended to lower it still further to 140° F. The average for forgings received by G.E. during 1958 was 95° F.

Work in Progress

This does not mean that all problems are solved. All details of the design of turbo-alternators now on order or proposed have been scrutinized to eliminate sharp mechanical notches. The following projects are also receiving concentrated attention by the development and applied research groups at Schenectady:


Devise more accurate and quantitative methods for extracting and identifying the tiny non-metallic inclusions, and formulate some method

acceptable to both steelmaker and electrical manufacturer so steels can be rated as to microstructure and by inclusion counts.

Several types of inhomogeneity are of interest. One is the segregation of elements from top to bottom and from surface to center of these large ingots. Improvement in this respect would decrease bottom and top discards and raise the yield, forging to ingot—now 40% or less. Another problem is the localized banding or pencil-shaped segregation streaks having different hardness and ductility from the surrounding metal. Such streaks of alloy-rich metal surround networks of sulphides or other inclusions. Whenever the apex of a notch in a test disk falls in such a streak, the fracture strength is low, and this causes most of the scatter in the data.

In cooperation with the suppliers of the forgings, the Schenectady men are making an extensive mathematical and physical study of the ingot solidification process to determine the mold and casting variables which must be controlled to improve uniformity and eliminate the last vestiges of pipe.

Another important study is of temper embrittlement, a characteristic of higher alloy steels of deeper hardenability. For example, 2.5 Ni, 1.3 Cr, 0.5 Mo, 0.1 V has a much lower FATT than the "standard" Ni-Mo-V when quenched in small pieces from tempering temperatures, and is stronger—but these advantages fade when a large forging cools slowly (as it must). As noted above, the A.S.T.M.'s committee is also concentrating on this mystery. Minor variations in composition seem to have a disproportionately large influence on temper embrittlement; perhaps the nigger in the woodpile is minute amounts of tramp elements, not analyzed for but doubtless existing. Minor variations in steel manufacturing may also exercise considerable influence.

Finally to be mentioned is a study of variations in the chemical analyses and processing. Extensive data on about 500 forgings have been collected. It requires seven I.B.M. punch cards to contain all the encoded results from each. It was recently desired to step up considerably the physical requirements for forgings for two machines on order. The punch cards were fed through the computing machine to find the optimum combination of composition, treatment and magnetic and mechanical properties. Three forgings (one spare) were ordered to such a specification. They met the requirements with exceptionally good properties! 

"Across-the-Line" Operation of Silicon Carbide Heating Elements

By W. E. MACER*

SILICON CARBIDE HEATING ELEMENTS can be connected "across-the-line" without transformers for economical metal processing up to 2000° F. They provide simplicity and versatility for heat treating and can be easily and quickly replaced without complete shutdown.

Elements vary in size from 4 in. long \times $\frac{1}{4}$ in. diameter to over 8 ft. long \times $2\frac{1}{2}$ in. diameter. They are made of self-bonded silicon carbide, material once used almost exclusively for grinding wheels, coated abrasives, and refractories.

The center or heating section of the elements has a resistance of approximately 0.1 ohm per cc. The terminal ends have much lower resistance. Thus, the heat developed in the terminal ends is only a small portion of the total input. Extremities of the terminals are metallized with aluminum to provide low contact resistance.

Elements are strong in compression but low in tensile strength and susceptible to damage from vibration and mechanical shock. However, either vertical or horizontal mounting is possible. In a typical horizontal installation, holes slightly larger than the diameter of the element are

drilled through the furnace walls. The terminal portions of the elements are then laid flat in the bottom of these holes so that the heating section spans the furnace chamber and the wall supports the elements. In vertical installations, heating rods are on adjustable mounting brackets.

Elements may be connected in parallel, series, or combinations of the two but only those which are matched should be connected in series. A new element should never be connected in series with a used one.

The input to heating elements connected "across-the-line" is controlled by the on-off method using an automatic pyrometer and magnetic contactor. Switches in the contactor coil circuit permit selected pairs or groups of elements to remain on at all times and others to be on-off controlled by the pyrometer.

*Refractories Div., Carborundum Co., Niagara Falls, N. Y.

Fig. 1 — Resistance-Temperature Characteristics of Silicon Carbide Heating Elements (Globar Delta)

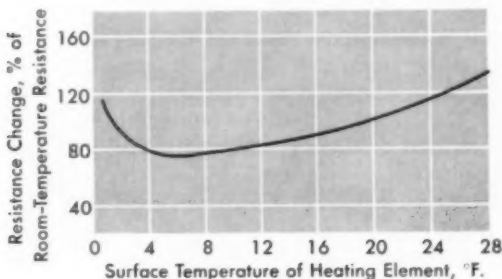
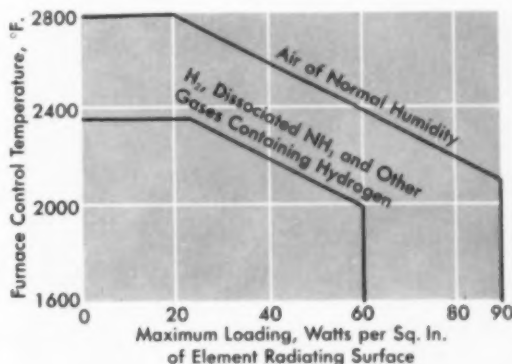


Fig. 2 — Maximum Watt Loading of Silicon Carbide Heating Elements (Globar Delta) in Relation to Furnace Chamber Temperature and Atmosphere



Resistance of the element varies with surface temperature. When a furnace is turned on, the resistance drops until the surface temperature of the element reaches about 800° F. in 2 to 5 min., then rises, as shown in Fig. 1.

All silicon carbide heating elements increase in resistance with use. Hence, when designing a furnace in which the rods will be operated directly off a 115 or 230-v. line or any fixed voltage, the rate of increase in resistance must be considered. Usually 25 to 50% overpower should be provided. If enough elements are installed so that the initial input to the furnace at operating temperature with new elements is 50% more than is required, it will be possible to obtain service from the elements until their resistance has increased 50%. Unless the elements can be reconnected, this would be the length of time they might be operated with on-off control at the original applied voltage.

Silicon carbide rods are more refractory than most metallic heating elements and can be operated at higher specific watt loadings and temperatures. Figure 2 shows the maximum power (watts per sq.in. of radiating surface) for operation at various temperatures and in different atmospheres.

Interest in electric furnaces which are equipped with silicon carbide elements is increasing. Across-the-line operation makes them more versatile. Long life, ease of replacement and maintenance, and low initial cost are attractive features to metals processors. The Sentry Co., Foxboro, Mass., for example, uses silicon carbide elements across-the-line exclusively in their metallurgical furnaces. Three of them are used by the Grobet

File Co., Inc., to heat treat rotary and chisel-cut files. Heat treatment is particularly critical here because the cutting edges and flutes of the files are formed by impact and must be protected during hardening. Hamilton Watch Co. uses two furnaces for experimental work on high speed steel alloys, and for production heat treating of miniature form cutters, reamers, and small drills.

The Electric Wire Co., North Hampton, Mass., has two furnaces in operation which use 32 silicon carbide elements across a 220-v. line. The firm produces small-diameter wire drawn from about 42 alloys including nickel, Monel, Inconel and stainless steel.

The first furnace, built approximately 18 months ago, still uses the original elements. They operate continuously between 2000 and 2250° F., occasionally at 1800° F.

Wire passes through the furnaces in Inconel tubes containing cracked ammonia. Production of stainless steel wire is approximately 6000 lb. daily. After 18 months' service, the increase in resistance of the elements has been negligible. ☼

Beryllium Heat Shield Forged by Heavy Press

Brush Beryllium Co. and Alcoa have combined their operations to produce a heat-absorbing shield for the nation's first manned spaceship. To produce this shield ("heat sink" in space slang), Brush first hot pressed a beryllium billet, 62 in. in diameter. A special process — involving simultaneous application of vacuum, heat and pressure to beryllium powder — did the job. After preliminary machining, the billet was encased in steel and shipped to Alcoa's Cleveland works for forging. There, the billet was first heated to about 2000° F. A huge manipulator then removed the steel-jacketed piece of beryllium, and placed it on a preheated die. Following this, Alcoa's 50,000-ton press, one of the largest in the country, squeezed the beryllium billet into the saucer-shaped disk, 80 in. across and 3 in. thick, shown in the photograph.

The forged part will be returned to Brush for precision machining. When the final operation — ultrasonic inspection by Alcoa — is completed, McDonnell Aircraft Corp. will receive the finished piece to install in N.A.S.A.'s Project Mercury capsule. ☼

Fig. 1 — This Saucer-Shaped Beryllium Disk Is Being Removed From Alcoa's 50,000-Ton Press After Forging. Aluminized suits protect the workers from the heat



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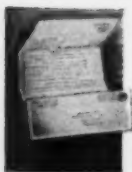
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Impact Test for Evaluating Toolsteels Discussed

BETHLEHEM, PA.

In "Impact Test for Evaluating Toolsteels", by Gary Steven, which appeared in the May 1959 issue of *Metal Progress*, p. 76, the author has accurately described the difficulties involved in impact testing of toolsteels. An even more difficult task—that of indicating how the impact values can be used—has not been attacked. In fact, this second task does not appear to have been recognized as a problem since the author says, in the closing paragraph: "As is evident, this new test is useful in comparing different toolsteel classes . . . The optimum heat treatment for a given grade of toolsteel can easily be established."

In my opinion it is not evident that this new impact test, or any impact test yet devised, is useful in comparing different toolsteel classes. Further, it will be difficult, if not impossible, to establish the optimum heat treatment for a given grade of toolsteel using impact test results.

The data shown in Table II of the article, comparing different toolsteel classes, can lead to serious misapplications of grades of steel. For example, cold header dies made of W 1 carbon toolsteel often fail in service in a brittle manner. Since the impact strength of D-2 high-carbon high-chromium toolsteel is shown as better than that of W 1 steel, it might be assumed that D-2 steel would be better than W 1 steel for this purpose. Experience proves that this is not so.

With respect to the observation that M-2 high speed steel shows higher impact strength after 600° F.

temper than conventional tempers at 1000 to 1050° F., it should be noted that many different types of impact tests have indicated the same thing in the past. However, cutting tools heat treated with tempers below 1000° F. have shown two serious deficiencies in service:

1. The tools do not cut efficiently.
2. The tools fail prematurely in a brittle manner.

Thus, the experience on production tools is directly contrary to the indications of impact tests.

It appears appropriate to apply the wisdom of a pioneer in material evaluation, H. W. Gillett*:

"A good engineer . . . thinks for himself and he maintains a healthy skepticism about measures that don't really measure. When he wants to know how a material is going to behave in service, he looks up what the handbooks have to say about it and finds it described in terms of conventional mechanical test values. But then he does not assume that those values tell anything more than how the material acts in the test. He does not assume that the behavior he wants in service is sufficiently implied by the conventional test results obtained under conditions not agreeing with service conditions.

"All in all, ductility values cannot be used directly in design. Even less direct application can be made of the figures for foot-pounds absorbed in a conventional notched-bar test, sometimes thought to measure toughness. There has been a wholly false impression that a material showing 40 ft-lb. Charpy is twice as tough and twice as good for severe

service as one of 20 ft-lb. Equally false is the idea, expressed in some specifications, that some particular value, often that of 15 or 20 ft-lb. energy absorbed by a conventional notched bar, represents a safe level of toughness. These values tell the behavior of the particular size and shape of specimen, and nothing else."

J. Y. RIEDEL
Toolsteel Engineer
Bethlehem Steel Co.

AUTHOR'S REPLY: I concur with Mr. Riedel that interpretation of the test results is the more challenging of the two—evaluation and application.

It is evident that one not skilled in the art of toolsteel application can be badly misguided by comparing numbers without regard to other factors, such as microstructure, operating stress system, and rate of load application. On the other hand, I feel that with an average background in toolsteel metallurgy one can readily compare steels which are metallurgically similar and select the tougher of two grades.

To cite the specific examples, in larger sizes the shallow hardening W 1 steel will have a tough core and a hard case in compression, insuring good fatigue resistance. The distribution of internal stresses in the through-hardening D-2 die, however, may or may not be conducive to long die life. This information was not implied in the test results presented in the article. Similarly, the impact resistance of high speed cutting tools must be examined in the light of tool performance experience.

On the other hand, the test data agree consistently with service experience which indicates that molybdenum-base high speed toolsteels

*"What Do Material Tests Really Tell the Designer?", by H. W. Gillett, *Machine Design*, October 1949, p. 96, 102 and 154.



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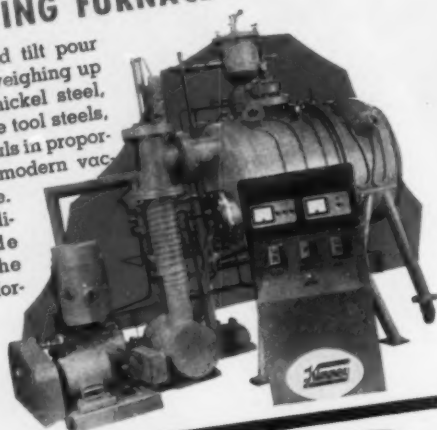


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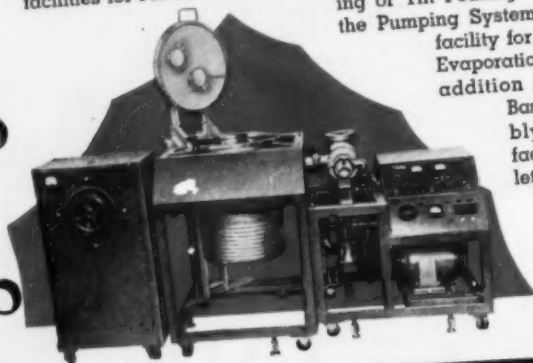
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(M-2) are generally tougher than tungsten base steels (T-1).

Similarly, the outstanding performance of LaBelle HT in many applications involving severe shock is paralleled by the high Charpy C-notch impact values of this grade.

We merely intended to present data on the toughness comparison of different steels using a test that appeared to be more selective than other tests used in the past. We did not wish to imply that toolsteel selection could be made on the basis of this test alone.

GARY STEVEN

A Further Look at Russian Steels

TORONTO, ONT.

We have read with great interest the excellent article "A Look at Russian Steels", by your consulting editor Arthur B. Tesmen, on p. 101 of the June 1959 *Metal Progress*.

However, we wonder about his source of information on the effect of arsenic content in the Kerch ores and in the Azovstal rails. According to the article: "In 0.75% carbon rail steels, 0.15 to 0.20% As was found to have no adverse effect upon strength and impact after aging nine months. Their investigations also established that weldability of rimmed and killed low-carbon steels was not affected until arsenic exceeded 0.20%."

The above statement seems to be in contradiction to an original Russian article concerning the same Azovstal steels ("The Effect of Arsenic and Phosphorous on the Impact Values of Rail Steel", by L. M. Shkolnik, *Stal*, No. 6, 1956, p. 548-553). We quote two sentences from that article's conclusions: "To avoid the influence of arsenic on impact values, it is necessary to decrease the phosphorous content of the steel; 0.1% As is compensated by decreasing the phosphorous 0.005% . . . The arsenic-contaminated Azovstal rails show a much lower impact value than the arsenic free rails of the same works."

Furthermore, the Czechoslovakian steel industry had to investigate the dangers of arsenic due to the growing import of the Russian Kerch ores. We quote here from the F. Benes (*Hutnicke Listy*, 1957, Vol. 1,



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Now, here are the results—the industry's most complete line—*28 ISOBRITE Brighteners with these most-wanted features:*

1. LONGER LIFE

Your own records will show ISOBRITE Brighteners give longest possible life in rack or barrel plating operations.

2. BRIGHTNESS

You'll see for yourself that ISOBRITE Brighteners give a diamond-like sparkle that just can't be matched.

3. THROWING POWER

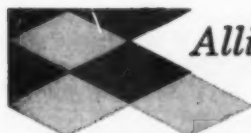
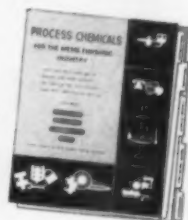
Even if your product has deep recesses, you'll get a uniform, all-over brightness that only ISOBRITE Brighteners can give you.

4. WIDER BRIGHT RANGE

ISOBRITE Brighteners operate efficiently over exceptionally wide current density ranges and have greater tolerance for temperature change.

Remember, there's an ISOBRITE Brightener especially designed for your specific operations—whether you're rack or barrel plating zinc, cadmium, copper or white brass . . . an ISOBRITE Brightener that is entirely compatible with most other brighteners. Don't just order brighteners—specify ISOBRITE. There is a difference!

Your Allied Finishing Systems Engineer will be glad to discuss the benefits of ISOBRITE Brighteners in your operations. He's listed in your 'phone book under "Plating Supplies." Or, write for technical data and product list giving details of your operations.



Allied Research Products, Inc. 4004-06 EAST MONUMENT ST., BALTIMORE 5, MD.

Branch Plant: 400 Midland Avenue, Detroit 3, Michigan

West Coast Licensee for Process Chemicals: L. H. Butcher Co.

Chemical and Electrochemical Processes, Anodes,
Rectifiers, Equipment and Supplies for Metal Finishing

IRIDITE
Chromate
Coatings

IRILAC
Clear
Coatings

ISOBRITE
Brighteners

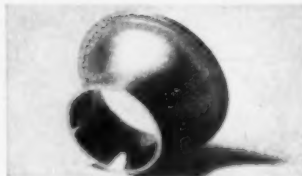
ARP
Plating
Chemicals

WAGNER
Equipment

LOOK WHAT FANSTEEL'S DOING WITH TUNGSTEN NOW!



Tungsten cup being drawn preliminary to shaping into missile hardware.



BIGGER TUNGSTEN NOZZLE THROAT INSERTS

Now made up to 4" flange diameter, 3" long, with wall thicknesses of 0.060"! Incredible six months ago... possible today... routine tomorrow at Fansteel!

AND... THESE TUNGSTEN CUPS NOW AVAILABLE FROM EXISTING DIES:



Fansteel will help you investigate the possibility of adapting Tungsten in your product. Call in the Fansteel man.

- $\frac{13}{16}$ " I. D. x .060" wall x $1\frac{1}{4}$ " deep
- $1\frac{1}{4}$ " I. D. x .060" wall x $\frac{1}{2}$ " deep
- $1\frac{1}{2}$ " I. D. x .060" wall x $\frac{3}{8}$ " deep
- $1\frac{5}{16}$ " I. D. x .125" wall x $\frac{3}{4}$ " deep
- $1\frac{5}{16}$ " I. D. x .125" wall x $\frac{7}{8}$ " deep
- $1\frac{1}{2}$ " I. D. x .040" to .060" wall x $2\frac{5}{16}$ " deep
- 2" I. D. x .060" to .080" wall x 5" deep
- $2\frac{5}{8}$ " I. D. x .125" wall x 2" deep
- $3\frac{3}{16}$ " I. D. x .125" wall x 1" deep
- $4\frac{1}{4}$ " I. D. x .125" wall x $1\frac{1}{4}$ " deep



**HIGH TEMPERATURE
METALS**

FANSTEEL METALLURGICAL CORPORATION North Chicago, Ill., U.S.A.

Correspondence . . .

p. 85-86): "It will be necessary to keep the arsenic content as low as possible with maximum 0.030 up to 0.040% to ensure the production of good quality steels. . . A positive method of arsenic extraction from the ores would be the only way in the future to prevent the arsenic content reaching the values which may be called critical."

P. T. VAJK
Metallurgist

British American Oil Co., Ltd.

AUTHOR'S REPLY: With reference to the effect of arsenic upon the properties of rail and low carbon steels, permit me to quote the conclusions of the article in *Stal* to which reference is made ("The Effect of Arsenic and Phosphorus on the Impact Values of Rail Steel", by L. M. Shkolnik, p. 553):

"1. While arsenic decreases the impact strength of rail, its detrimental effect is much weaker than that of phosphorus, especially at lower temperatures. The detrimental effect of phosphorus upon impact strength increases at lower temperatures while that of arsenic decreases.

"2. In order to minimize the influence of arsenic upon impact strength, it is necessary to reduce the phosphorus content; every additional 0.1% As can be compensated for by a decrease of 0.005% in phosphorus.

"3. While Azovstal rails containing arsenic have lower impact characteristics than those free of arsenic, it was found that the lower properties are due to the presence of phosphorus, rather than the arsenic."

Subsequent work at the Paton Electric Welding Institute (*Stal*, No. 7, 1956), Azovstal and Ukrainian Institute of Metals (*Stal*, No. 8, 1958) have established that rimmed and killed low-carbon steel containing up to 0.20% As are weldable (one investigator allows up to 0.29% As) with no detrimental effect upon their mechanical properties, and that the impact characteristics of rail steels (aged nine months) were not detrimentally affected by presence of up to 0.13 to 0.25% As.

These findings agree with F. Benes' statement: "It will be necessary to keep the arsenic content to a maximum of 0.030 to 0.040% . . ."

ARTHUR B. TESMEN



For maximum efficiency in the production of specimens in the metallurgical laboratory the Buehler cabinet type polishing table with companion storage cabinets represents the latest modern development of this type of equipment.

The convenience of this streamlined polishing equipment saves time and encourages the operator to produce the highest quality of polished sample.

Item No. 1511 is a two-unit polishing table with Formica top approximately 60" long x 27" deep x 30" high to table top. Two 12" swing spouts, drain, 8" diameter wash bowl, plumbing, and wiring.

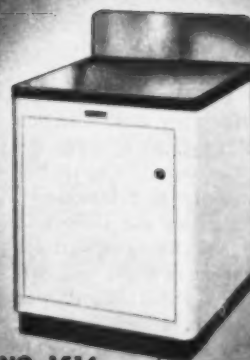
Recommended accessories to complete an efficient set up for maximum convenience are: No. 1512 storage cabinet with recessed light and No. 1513 supporting panel for installation above polishing desk. Or, No. 1514 floor model storage cabinet. Both these cabinets can be used together to advantage in most laboratories.

The Formica top and back on the table and cabinet is installed with a smooth Formica edge that eliminates all metal rims that may form pockets for water and dirt. Covers are held in place on the back by magnetic holders. The large 8" wash bowl is a new feature that enables the operator to use both hands in washing specimens.

All metal construction finished in hammer tone grey makes a very attractive appearance.

Prompt delivery can be made on these new items.

The Buehler Line of Specimen Preparation Equipment Includes . . . Cut-Off Machines • Specimen Mount Presses • Power Grinders • Emery Paper Grinders • Hand Grinders • Belt Surfaceers • Mechanical and Electro Polishers • Polishing Cloths • Polishing Abrasives



NO. 1514

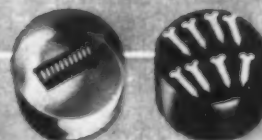


NO. 1511

Buehler Ltd.

METALLURGICAL APPARATUS

2130 GREENWOOD AVE., EVANSTON, ILL.



Personal Mention



Walter R. Hibbard, Jr.

WALTER R. HIBBARD, Jr. ☉, manager of the alloy studies section of the metallurgy and ceramics department at the General Electric Research Laboratory in Schenectady, N. Y., was awarded the 1959 Yale Engineering Association Award for the Advancement of Basic and Applied Science. Dr. Hibbard was cited as a "scientist and engineer, metallurgist of international reputation . . . [who] has carried over into his industrial research affiliation a continuing interest in the teaching of our youth."

A graduate of Wesleyan University, he received his doctorate in physical metallurgy from Yale in 1942 where he subsequently served as assistant and later as associate professor. A member of the staff of the Research Laboratory since 1951, he has been active in the leadership of the American Institute of Mining, Metallurgical and Petroleum Engineers and American Society for Metals.

Two years ago he was one of a group of American scientists who toured Russia under the sponsorship of the U. S. State Department, studying Soviet education and research in the field of metallurgy.

Russell A. Hastings ☉ has been elected executive vice-president of the K. H. Huppert Co., Chicago.

Edward O. Falberg ☉ has been promoted to division manufacturing manager of Bohn Aluminum & Brass Corp., Detroit, with responsibility for the manufacturing operations of Bohn's plants in Greensburg, Ind., and Holland, Mich. For the past five years, Mr. Falberg has held various plant management posts with the company, and was assigned to the Greensburg plant before his recent appointment.

John G. Ziemann ☉ has been promoted to assistant chief metallurgist in the Metals Div. of Kelsey-Hayes Co., New Hartford, N. Y. Mr. Ziemann, who will be in charge of special projects in connection with alloy production, has been connected with the company since 1957 as a research metallurgist.

Arthur H. Vaughan ☉, chief engineer of the Electric Furnace Co., Salem, Ohio, has been awarded the Trinks Industrial Heating Award. Mr. Vaughan was cited for his conspicuous achievement in designing over 2900 special furnaces in a career spanning 27 years.

A. V. Orr ☉ was recently appointed manager, Canadian sales, for Atlas Steels, Ltd., Welland, Ont. Mr. Orr has served as sales engineer for Atlas in the Vancouver, Toronto and Niagara districts and more recently as manager of toolsteel products for the company.

C. F. Koehler, Jr., ☉ was appointed assistant vice-president of Wyckoff Steel Co., Pittsburgh, at the recent annual stockholders meeting of the company.

Manuel Tama ☉ has been named vice-president in charge of the Ajax Magnethermic Corp. engineering division in Trenton, N. J. Mr. Tama has been with Ajax since its formation in 1941 as vice-president and since 1958 as president. Earlier this year, two Ajax companies were joined with the Magnethermic Co. to form Ajax Magnethermic Corp.

Arthur W. Donkin ☉ recently joined Mechanical Spring Fabricators, Inc., Chicago, as vice-president and general manager. He was formerly associated with the development department of Air Reduction Sales Co., Union, New Jersey.

K. H. Carlson ☉ has been appointed technical manager of specialty steels for the Latrobe Steel Co., Latrobe, Pa., in charge of technical development and service.

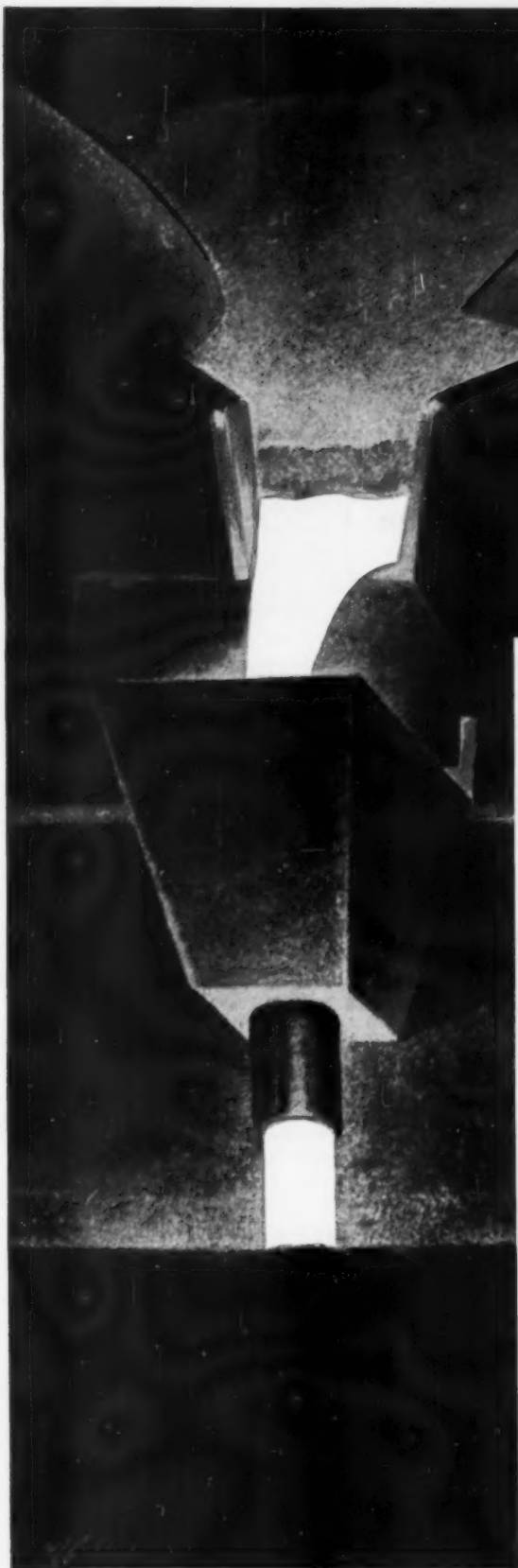
Dillon Evers ☉ has been named manager of the sponsored research group, a newly formed department at Mallory-Sharon Metals Corp., Niles, Ohio, created to carry out research and development projects on special metals for the government. Dr. Evers joined Mallory-Sharon in 1956 and until his recent appointment was staff technical advisor to the company's research and development department.

Martin J. Dempsey ☉ has been appointed product metallurgical engineer in the Crucible Steel Co. of America's technology department, assigned to the Pittsburgh office. Formerly manager of the company's Detroit sales branch, he joined Crucible in 1941 as a metallurgist at the Spaulding Works in Harrison, N. J., transferring to Pittsburgh and then the Detroit sales branches.

Edward J. Mammanna ☉ was recently assigned to the New York district office of Riverside-Alloy Metal Div., H. K. Porter Co., Inc., where he will cover portions of the New York City area from the division's office in East Orange, N.J. Mr. Mammanna, who was formerly associated with Crucible Steel Co. of America in a sales-service capacity, joined the company in February and received his appointment after completing an intensified mill familiarization course.

O. M. Haseltine ☉ has been named sales manager of Ajax Electric Co., Philadelphia. A charter member of the Chicago-Western Chapter ☉, he formerly served Ajax as sales engineer in the Chicago and Midwest territory.

Italo S. Servi ☉ has been named director of research in charge of all research and development activities for the Metals Div., Kelsey-Hayes Co., New Hartford, N. Y. Dr. Servi had been affiliated with the Union Carbide Metals Co. research laboratories at Niagara Falls, N. Y., since 1951, and last held the post of manager of the corporation research group.



New
"washing machine"
makes CLEAN
stainless steel

More often than not, titanium-bearing stainless can hike your fabrication costs . . . due to subsurface stringers or banding that cause excessive scrapping of parts. At Eastern, however, these harmful inclusions come out in the "wash."

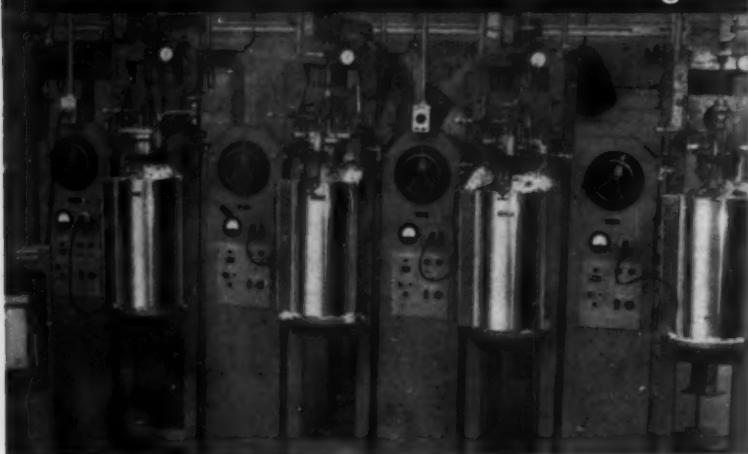
Eastern's exclusive slag wash melting process produces the *cleanest* titanium-bearing stainless you can buy . . . exceptionally free from non-metallic contaminants . . . and at *no extra cost*. Eastern's new high-capacity slag furnace will meet industry's growing demand for such titanium-bearing steels as 321SW, 19-9DL, A-286, 19-9DX. Which do *you* need—and how fast?



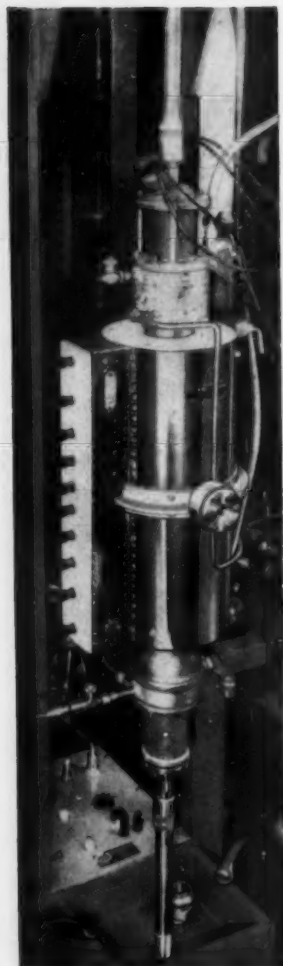
EASTERN
STAINLESS STEEL

Baltimore 3, Maryland, U. S. A.

Marshall Furnaces at Oak Ridge



1000 to 1800° F ± 1.5°



At Oak Ridge, Marshall furnaces accurately maintain set temperature levels in the range of 1000 to 1800° F., within $\pm 1.5^\circ$ F. The furnaces are vital components of specially designed and built gaseous and vacuum creep rigs. Creep properties of structural metals are tested under the effect of high temperature gases, vacuum, various liquids, and liquid metals. The rigs were developed by the Oak Ridge National Laboratory, operated by Union Carbide Corporation for the U. S. Atomic Energy Commission, and the furnaces were built to their specifications by Marshall Products Co. After more than four years of virtually continuous service, all major components are still in operation!

This accuracy and dependability is typical of Marshall furnaces used widely as components of machines for creep testing metallic alloys, and also for tensile, stress-rupture, and fatigue testing of metals, ceramics and cermets.

Marshall offers a range of standard tubular, shunt-type furnaces compactly designed to apply electrical heat up to 2600° F, under exact control. Units feature uniform temperature distribution and rigid zone control to $\pm 3^\circ$ F at any point in the test zone. Under certain conditions operators report temperatures can be held to $\pm 1^\circ$ F. Test durations may range from moments to 10,000 or more hours.

MARSHALL PRODUCTS CO.

tubular furnaces and control panels

270 W. LANE AVENUE, COLUMBUS 2, OHIO



write today for
complete information

Liquid-metal creep testing frames (shown at top)
Creep testing in various gaseous environments (left)

Personals . . .

Kenneth P. Seeger is now chief metallurgist on the staff of Precision Extrusions, Inc., Bensenville, Ill. Active in the aluminum extrusion field for the past 18 years, Mr. Seeger was formerly plant metallurgist for the Aluminum Co. of America at Lafayette, Ind.

Thomas H. Mitchell has joined Calstrip Steel Corp., Los Angeles, as metallurgist in charge of quality control for stainless steel strip, low-carbon and spring steel strip.

Russell V. Bobb, assistant manager of the extrusion division of Reynolds Metals Co., Richmond, Va., has taken over supervision of the company's extrusion plant in Phoenix, Ariz.

E. L. Milford, a veteran of 18 years' experience in the heat treating industry, has been appointed sales engineer in the Chicago and midwestern area by Ajax Electric Co., Philadelphia.

Ralph D. Wysong, manager of manufacturing research for Studebaker-Packard Corp., South Bend, Ind., was recently elected national president of the American Electroplaters' Society at the organization's Golden Jubilee Convention, held in Detroit.

Louis V. Abrams, recently employed in management consultant work, has joined Pangborn Corp., Hagerstown, Md., in the newly created post of administrative assistant to the president.

George E. Meyer, formerly at Rensselaer Polytechnic Institute, has joined the staff of the Oak Ridge Y-12 Plant of the Union Carbide Nuclear Co. in Oak Ridge, Tenn. At the same time, **Ralph G. Donnelly** and **George Hallerman**, from Case Institute of Technology and Columbia University, respectively, have become members of the Oak Ridge National Laboratory.

Adam MacKenzie has been appointed marketing manager of the General Electric Co. lamp metals and components department in Cleveland. Associated with General Electric for 35 years, he was formerly manager of the department's Cleveland weld plant.

↓
J&L, too, relies
on *Lee Wilson*
single stacks for
finest chrome-stainless annealing!

**No special atmosphere required...
uniformity of physical properties
declared excellent**

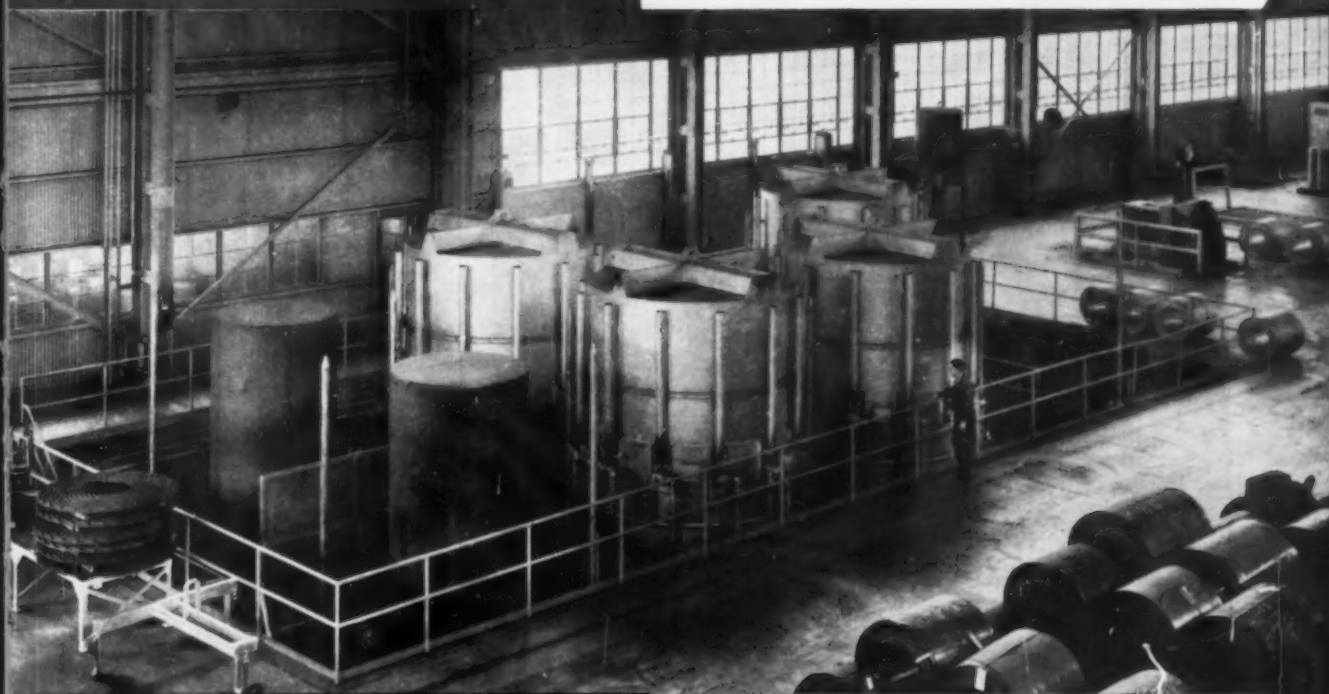
—Exacting uniformity of anneal is particularly desirous in chromium stainless steels. To make sure of the finest possible annealing Jones & Laughlin selected Lee Wilson single stack furnaces for their new Stainless and Strip Division plant at Louisville, Ohio.

No special atmosphere is required. The anneal develops a type of scale which is easily removed. The four furnaces and eight bases have capacity for 2800 tons per month.

Designed specifically for stainless annealing the installation includes cast alloy convector plates, oil-lubricated fan drive and alloy fan wheel designed to operate up to 1600°F. Because charges are uncovered at high temperatures heat shields have been installed between bases.

Standard or special Lee Wilson single stack furnaces are unequalled when it comes to quality, production and versatility.

finest chrome-stainless annealing!



Jones & Laughlin can process 2800 tons per month of chrome-stainless through the four Lee Wilson single stack annealing furnaces pictured above.



Lee Wilson[®]

**ENGINEERING
COMPANY, INC.**

20005 LAKE ROAD • CLEVELAND 16, OHIO

HIGH PRODUCTION ANNEALING SYSTEMS
MAKE THE BEST METALS BETTER

© ORIGINATORS AND LEADING PRODUCERS OF OPENED COIL AND SINGLE STACK FURNACE

For almost every hardness testing requirement **There's a Wilson "Rockwell"** **instrument to do the job**

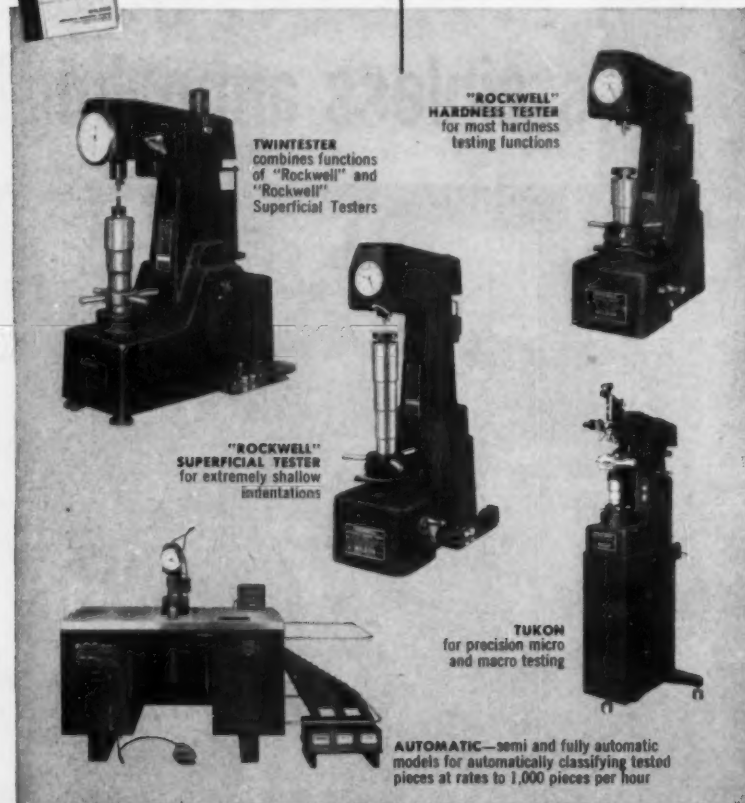
Wilson "Rockwell" Hardness Testers can help make your products better, stronger, longer lasting. They give reliable results on the production line, in laboratories, in tool rooms, and in inspection departments. They're as easy to use as a center punch, as durable as a machine tool, as sensitive and accurate as a precision balance. That's why Wilson "Rockwell" is recognized as the world's standard of hardness testing accuracy.

Wilson "Brale" Diamond Penetrators give Perfect Readings

A perfect diamond penetrator is essential to accurate testing. Only flawless diamonds are used with Wilson "Brale" penetrators. Each diamond is cut to an exact shape. Microscopic inspection and a comparator check of each diamond—one by one—assure you of accurate hardness testing every time.



Write for Catalog RT-58.
It gives complete details on the full line of Wilson hardness testing equipment.



WILSON "ROCKWELL" HARDNESS TESTERS

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-F Park Avenue, New York 17, New York



Personals . . .

Amos J. Shaler, head of the department of metallurgy at Pennsylvania State University, is on a year's sabbatical leave in Belgium, with headquarters at the European Research Associates research laboratory in Brussels. This group will be sponsoring some of his work in Europe. During the next year, he will do some writing, study in the field of nuclear materials, do a little research in powder metallurgy and travel to universities, research laboratories and industrial plants.

John G. McMullin has resigned as supervisor, metallurgy applied research, for the large steam turbine-generator department of General Electric Co., Schenectady, N. Y., to accept a position as supervisor, structural alloy research, in the central research laboratory, Crucible Steel Co. of America, Pittsburgh.

Adna A. Armstrong, formerly manager, process control laboratory, valve division, Thompson Ramo Wooldridge Inc., has been appointed manager of metallurgy for Burgess-Norton Mfg. Co., Geneva, Ill.

Richard J. Quigg recently received his doctorate degree from Case Institute of Technology and is now employed as a research metallurgist for Thompson Ramo Wooldridge Inc., Cleveland.

David L. McElroy, formerly associated with the University of Tennessee, and Thomas D. Watts, from the University of Wisconsin, have been appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn.

John J. Horner has been promoted to industrial manager of the Philadelphia branch office of Minneapolis-Honeywell Regulator Co. Mr. Horner has been with Honeywell since 1937, as an industrial service engineer and then as a salesman.

Peter Leckie-Ewing has joined the metallurgical staff of Latrobe Steel Co., Pa. He was formerly associated with Landis Machine Co. of Waynesboro, Pa., in the position of chief metallurgist.

William P. Ziegler, Jr., has been appointed national sales manager of Kolene Corp., Detroit. He joined the company in 1949.

*Good news in
Anti-friction action...*



SWIFT now offers a FAMILY OF FIVE...

Swift's new line of high heat resistant, long mileage lubricants are now available to serve a variety of drawing and metal processing jobs.

Flexals are extremely versatile. A wide range of chemical and physical properties makes them particularly adaptable for difficult or highly specialized jobs. For example: Flexals can be furnished for cold heading, hot dip coating and dry drawing of high or low carbon wire. They can be soluble in water . . . or *insoluble* in both water and solvents. Melting points range to 800° F. They are offered in controlled grinds down to micron particle size.

Look over Swift's new *Family of Five FLEXALS* . . . with your process in mind. Then, write for details on a trial order of these versatile new ANTI-FRICTION lubricants.



FREDDIE FLEXAL
invites your
further inquiry.

**FLEXAL
S**

Hot dip, dry film lubricant and rich, dry drawing compound.

**FLEXAL
CS**

Fine calcium stearate; 58°-60° C. titer, 325 mesh.

**FLEXAL
MCA**

Metallic stearate base. Medium vari-grind compound.

**FLEXAL
MCF**

Metallic stearate base. Rich, fine mesh drawing compound.

**FLEXAL
MCL**

Lean, fine, dry lubricant for low carbon bright and cold heading wires.

*To Serve
Your Industry
Better*

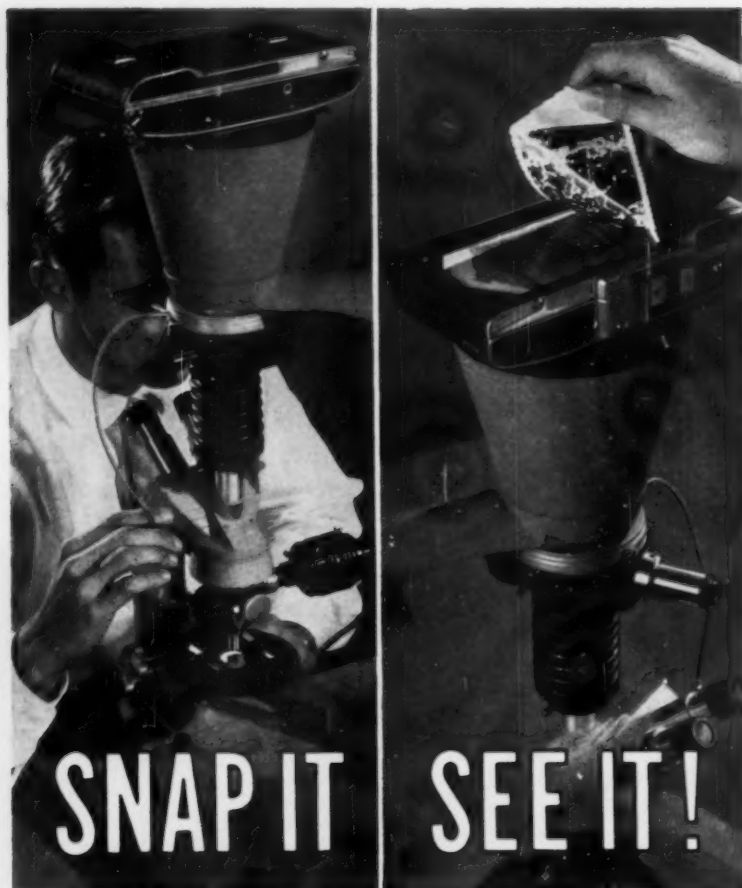


5-53R

SWIFT & COMPANY • SOAP DEPARTMENT • 4115 Packers Ave., • Chicago 9, Ill.

SEPTEMBER 1959

141



AO Spencer Picture-in-a-minute Photomicrography

When you use the AO Spencer Photomicrographic Camera equipped with the Polaroid® Land Camera back, permanent photographs are ready for your files in just 60 seconds. A coupled visual and photographic system lets you shoot what you see . . . quickly and effortlessly. And with the Polaroid back possible errors in exposure, illumination or focus can be corrected immediately.

In addition to the Polaroid Land camera back, you have a choice of 4 other *readily interchangeable* camera backs; 4" x 5" fixed back; 4" x 5" Graflex back; 35mm back and Bantam back (roll film). You choose the camera back and film best suited to your specific requirements.

Here, the No. 682G Camera is shown being used with the new AO Metalstar Metallurgical Microscope . . . an ideal combination. The stage is focusable . . . your eye level remains constant . . . also, because the vertical illuminator remains at a fixed height throughout all focusing adjustments, you can conveniently use an external light source in place of the illuminating unit.

The sturdy vertical pillar, the easily adjustable camera support, the camera back and the Metalstar all combine to provide a compact unit. Perfect alignment and rigidity is assured . . . successful photomicrography becomes a "snap".

Try it and see for yourself. Your AO Representative will be happy to arrange a demonstration for you.



Dept. U119

☐ Please send me Brochure SB682 describing the entire line of AO Spencer Photomicrographic Cameras.

☐ Please send me Brochure SB2200 describing the new Metalstar.

Name

Address

City Zone State

Personals . . .

Julian Glasser and **William E. Few** are now associated as consultants in chemical and metallurgical activities in Chattanooga, Tenn., offering services to industry and government. Mr. Glasser, formerly technical director at Cramet, Inc., Chattanooga, had been operating a consultant practice for the past year, while Mr. Few was technical assistant to the general sales manager, alloy and metal division, Tennessee Products and Chemical Corp., Nashville, Tenn.

Charles N. Zimmermann has been appointed senior sales engineer for the New England territory of the Brush Beryllium Co., Cleveland, with headquarters in Boston. At the same time, **L. Dean Alspach**, formerly sales engineer for the company, was promoted to district manager in charge of sales territories in Indiana, Ohio, Kentucky, Western New York and Eastern Ontario. Mr. Alspach was a founder of Penn Precision Products in Reading, Pa., now the Pennrold Div. of Brush.

Daniel S. Steelman was recently named director of purchasing by Fischer & Porter Co., Hatboro, Pa. Formerly purchasing agent, Mr. Steelman has been with the company for 17 years.

David W. Mitchell has been assigned as coordinator, research and production, for Foote Mineral Co., Philadelphia. In addition to his new assignment, Dr. Mitchell will continue to act as manager of minerals research. He will be located at the company's research and development laboratories in Berwyn, Pa. Since joining Foote in 1957, he has been engaged in mineral beneficiation research at the lithium mine at King's Mountain, N. C.

John H. Dasdorf has been assigned to the Los Angeles district office of Jones & Laughlin Steel Corp., Pittsburgh, as a service metallurgist, stainless and strip division.

George O. Hiers, consulting metallurgist, Baldwin, N. Y. was presented with an award of merit in recognition of his long-time active participation in A.S.T.M. work especially in the field of nonferrous metals.

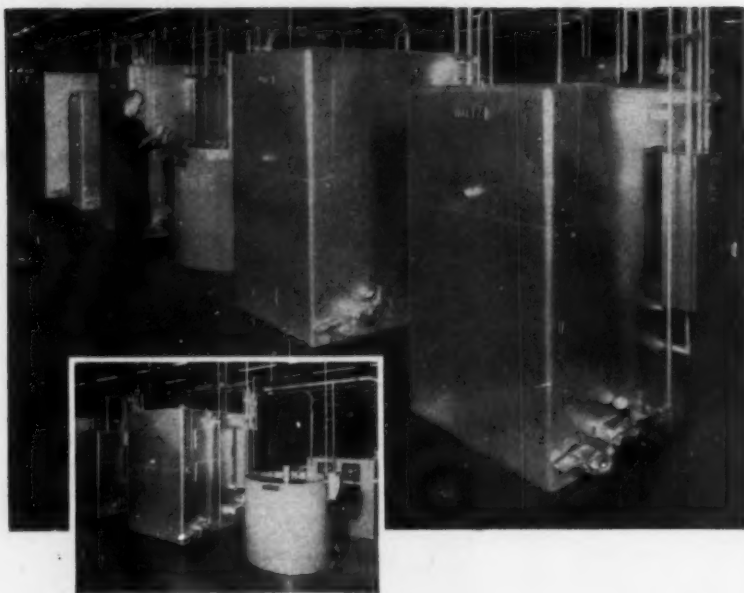
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Simple arithmetic and common sense establish the pattern. It's simply a matter of making high quality, *long-lasting* abrasives. The less you use, the more money you save. Take Cleveland High-strength "A" iron shot and grit. Greater abrasive life and decreased machine maintenance costs offset any minor increase in initial costs. Bargain prices cut no ice . . . ever.

Also write us today for more information, together with new catalog No. 159, or call our nearest representative.

1. Realsteel Shot and Grit 2. Pearlitic Malleable 3. Normalized
4. "A" Iron 5. Hi-Strength "B" 6. Chilled Iron 7. Cut Wire

the CLEVELAND metal abrasive company



Waltz furnaces have

the forward look ➤

at Chrysler Corporation

When equipping Chrysler Corporation's new TorqueFlite automatic transmission plant at Kokomo, Indiana, Chrysler engineers demanded equipment capable of top performance. WALTZ Furnaces were selected for the automotive tool room.

In addition to delivering the performance required, Waltz Furnaces also are attractive, smooth, easy-to-clean. Outer shells reach all the way to the floor to prevent unsightly and dangerous clutter usually found under ordinary furnaces. Waltz doors fit flush and tight, are opened with a convenient foot pedal control. Cabinet-type control panels are neatly wired to terminal blocks for easy installation.

Performance-appeal? Waltz has plenty. Just try to match the amazing versatility of a Waltz furnace. Originally installed by Chrysler just to handle the needs of the automotive tool room, the furnaces shown in the illustration were soon called on to handle many pilot parts, as well as regular production runs. Chrysler stayed right on schedule. So can you!

A complete line of Waltz standard or special heat-treating furnaces, using all types of fuels, is built to suit your requirements. Write for comprehensive illustrated bulletins to Dept. W.

Choice Distributor Territories Now Open

Waltz FURNACE COMPANY

SYMMES STREET • CINCINNATI, OHIO

Personals . . .

Bernard Kopelman ☼ has been appointed technical director for the Beryllium Corp., Reading, Pa. He joined Sylvania Electric Products' central research laboratories in 1944 and ten years later became chief engineer of the newly formed Sylvania-Corning Nuclear Corp. In 1958 he rejoined Sylvania as manager of electroluminescent engineering.

Donald C. Atkins ☼ has been named director of the new technical department of United States Chemical Milling Corp., Manhattan Beach, Calif. For the past two years he has been assistant chief engineer for the concern.

Karnig A. Berberian ☼ has joined Tang Industries, Waltham, Mass., as manager of materials. He was formerly employed by Raytheon Co. in the semiconductor division as pilot plant materials engineering group leader.

Henry Hubbell ☼, formerly chief metallurgist for the Fafnir Bearing Co., New Britain, Conn., has been promoted to technical development manager. **Philip K. Pearson, Jr.**, ☼, who joined the Fafnir metallurgical laboratory in 1950, will succeed Mr. Hubbell.

C. H. Toensing ☼, for eight years research and development engineer for the lamp metals and components department of General Electric Co., has been appointed manager, powder metals research at Firth Sterling Inc., Pittsburgh.

Norman D. Groves ☼ and **Neil J. Culp** ☼ have been promoted to assistant managers of research in the metallurgical department of Carpenter Steel Co., Reading, Pa. Mr. Groves, a corrosion engineer for Carpenter since 1956, was named assistant manager of research in charge of chemistry and physics, while Mr. Culp, formerly supervisory metallurgist of the alloy development group, was made assistant manager of research in charge of metallurgy.

Daniel L. Wertz ☼ is now directing the development and marketing of a new line of automated batch-type controlled atmosphere furnaces. Mr. Wertz is a past chairman of the Detroit Chapter ☼.



ONE SOLVENT — TWO JOBS

Now you can use one grade of trichlor
for both...Nialk trichlor with **psp**

Now you take trichlor for missile flushing and vapor degreasing out of the same drum.

The *metal degreasing* grade of Nialk® trichlorethylene meets industrial specs for flushing missile and rocket components. Its residue count is a low 0.0005%. It meets impact sensitivity requirements.

Save storage space. You can cut inventory to the bone with this single grade of trichlor. The savings in time and money are obvious.

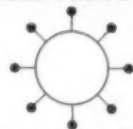
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Send for bulletin. Data Sheet 814 should answer any questions you have about Nialk trichlor. Write for a copy.

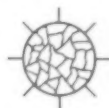
DOES YOUR SOLVENT SOUR?



1. Trichlor is protected by stabilizers against heat, air, light, moisture, acids, and active metals.



2. Ordinary stabilizers wear out during use, making it necessary to titrate and add fresh stabilizer.



3. A sour solvent can even stain metals instead of cleaning them; affects bath operation, too.



4. Nialk has **psp**... permanent staying power. Always gives you full protection. Never gets sour.

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HEAT



GENERAL ELECTRIC DESIGNS NEW FURNACE FOR HIGH-TEMPERATURE VACUUM OPERATIONS

Versatile new radiation shield furnace breaks heat barriers of conventional furnaces for critical super-alloy heating jobs

These new General Electric radiation shield furnaces give you faster heating and cooling cycles than you can obtain with your present hot retort furnaces. But in addition, they offer unmatched versatility for your future heating needs which hot retort furnaces can't possibly handle.

G-E radiation shield furnaces have been designed to operate from 1900 F to 2600 F, and in smaller sizes up to 4200 F. They can be used with vacuum, or with inert or hydrogen atmospheres. They are readily adaptable for the heat treatment, brazing and sintering of super-alloy stainless steel, and metals like titanium and zirconium.

In addition to the versatility of higher temperatures and atmospheres, there's no metal retort between the heating units and the work in a radiation shield

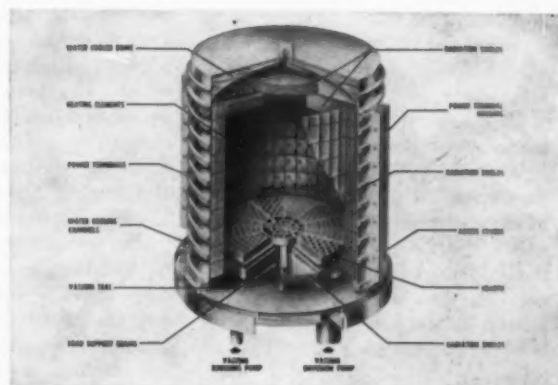
furnace. You get fast heating. And rapid cooling rates are provided by G.E.'s new cooling system that allows rapid recirculation of the cooling medium. Because of the more rapid heating and cooling cycles, a single radiation shield furnace can often do the work of a hot retort furnace with two bases and retorts . . . and give you substantial savings in floor space.

If you heat treat super alloys, seriously consider the advantages of a new G-E radiation shield furnace. You'll find General Electric engineers have the knowledge and design skill to match a furnace to your needs. Call your G-E Heating Specialist. Contact your nearby General Electric Apparatus Sales Office, or write Section 721-24, General Electric Company, Schenectady 5, New York.



TYPICAL APPLICATIONS	Stress Relief	Annealing	Brazing	Sintering	Solution Heat Treatment	Degassing
Stainless Steels	X	X	X	X	X	X
Super Alloys	X	X	X	X	X	X
Tungsten	X	X	X	X	X	X
Tantalum	X	X	X	X	X	X
Molybdenum	X	X	X	X	X	X
Columbium (niobium)	X	X	X	X	X	X
Titanium	X	X	X	X	X	X
Vanadium	X	X	X	X	X	X
Zirconium	X	X	X	X	X	X
Hafnium	X	X	X	X	X	X

Chart shows wide range of applications possible with G.E.'s new radiation shield furnace; typifies G.E.'s ability to provide correct heat treating equipment to meet almost every need.



The new radiation shield furnace is another example of General Electric pioneering in the field of high-temperature heat treating. This furnace is rated from 1900 to 2600 F, in smaller sizes up to 4200 F.



Metals Engineering Digest

... Interpretative Reports of World-Wide Developments

Solid Lubricants

A digest of "Solid Lubricants", by A. J. Stock, Acheson Colloids Co., Port Huron, Mich. Paper presented before the American Society of Lubrication Engineers, Buffalo, N. Y., April 21, 1959.

SOLID LUBRICANTS have many advantages. Unlike liquids, they cannot be squeezed out when two surfaces approach boundary lubrication conditions. They will retain their lubricating properties over a long period of downtime. (No re-lubrication is necessary after extended periods of storage.) They can be relatively insensitive to high temperatures, extreme atmospheres and vacuums. Their excellent load-carrying capacity makes them valuable where fluid lubricants would break down.

Of course, there are certain disadvantages. Before tetrafluorethylene resin (TFE) dispersions were developed, solid lubricants were black, and could not be used widely where personnel would contact them. Also, solid film lubricants do not dissipate heat as well as do metals in conjunction with fluid lubricants. Thin films of solid lubricants are not self-healing so they do not last as long as a fluid system in which the fluid can be changed and renewed continuously. Although solid lubricants have exceedingly low friction coefficients, they are still not as low as those obtained

with normal lubricating fluids. One must always balance these advantages and disadvantages when considering solid lubricants.

Solid lubricants can theoretically be used in four ways: bulk solids, thin films, dispersed in liquids, or dispersed in greases. All are useful to industry. Today, the most important types are graphite, molybdenum disulphide and the various plastics such as nylon and Teflon*.

Graphite, the first solid lubricant to be extensively used, is a lamellar solid. In other words, carbon atoms are in layers with certain well defined patterns. Cohesive forces between the layers of carbon atoms are much weaker than the forces between the atoms in the layers. One theory maintains that slippage between planes gives the lubrication effect. Graphite, of course, is pure carbon and it is obtained either from natural or synthetic sources. It retains its excellent friction qualities and inertness to chemical reaction to 1000° F. and above.

The second familiar solid lubricant is molybdenum disulphide. Another lamellar solid, this is a chemical compound in which alternate layers are formed of molybdenum and sulphur. It has about the same low friction as does graphite. In addition, it has a higher resistance to load. This makes it very useful for extreme pressure applications.

*Registered trademark of E. I. du Pont de Nemours & Co., Inc.

However, molybdenum disulphide does not have the chemical resistance of graphite. Also, when it decomposes, it forms various hard oxides which can grind rather than lubricate. Because of this, the friction, although low at room temperature, rises quite severely above 700° F. Molybdenum disulphide thus finds much use where extremely low frictions, high loads and relatively low temperatures are combined.

The third significant solid lubricant is tetrafluorethylene resin or TFE (duPont's Teflon). This is a plastic and is much used for its very low friction coefficient (about 0.04). So far, TFE and other plastic lubricants have been used as bulk solids, as thin films or as grease additives. (It has excellent chemical and thermal resistance up to about 600° F. Relatively soft, it performs best as a thin film particularly when combined with bonding resins. It is also rather hard to wet and it sticks poorly, which can sometimes be advantageous.

Another important plastic lubricant is nylon which is mostly used in bulk solid for bearings. Though not as low in friction as TFE resins, it is much harder and can be used without lubrication where the loads are relatively high and speed is low. It is not overly resistant chemically or thermally. However, its low price, compared to TFE, makes it much more useful in ordinary applications. (Cont'd. on p. 148)



To keep immersion heating jobs moving . . .

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Thirty-two ton Kemp Immersion Melting Pot keeps production on a 24 hour basis at Stanley Works, New Britain, Conn. Steel strapping is annealed on a continuous basis with important savings in time and fuel costs.

Where speed plus a high degree of control counts, depend on Kemp Immersion Heating Units. Kemp units give you sensitive and accurate control of heating needs for annealing, tempering, melting soft metals, and in many other applications.

Unique Kemp design puts the heat where it belongs . . . next to the material being heated. It goes to work immediately, without wasting time heating heavy pots, practically eliminates overrun and lag. The Kemp Industrial Carburetor, the basis for Kemp engineering design, premixes fuel gas and air to optimum ignition conditions. You get a cleaner operation with appreciable savings on fuel costs.

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Capacities from 1 to 75 tons—melting rates up to 26 tons per hour. For more information and practical suggestions, call in your Kemp Representative or write us direct for Bulletin IE-11. *The C. M. Kemp Mfg. Co.,* 405 E. Oliver St., Baltimore 2, Md.



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NOW GET CASTINGS AS CLEAN AS THIS . . . AND SAVE MONEY



ROTOBLAST
cuts cleaning
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bone—
adds new
dollars
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The casting above was Rotoblast cleaned at new low cost made possible by Rotoblast Steel Shot. Although cleaning cost per casting may seem a small part of your overall production cost, its efficiency often spells the difference between big and small profits on the finished job. Rotoblast assures you *maximum profit*.

Why? Because Rotoblast shot starts as a better-made steel, low in phosphorus and sulphur, produced in modern electric furnaces. Because Rotoblast shot uses an exclusive casting method to produce solid shot. Because Rotoblast is continuous-heat treated in a controlled atmosphere — another exclusive — to give you uniformity and the right hardness for fast cleaning and long wear.

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Pangborn

**ROTOBLAST
STEEL SHOT
AND GRIT**

Solid Lubricants . . .

Sapphire and diamond can be considered to be solid lubricants since they exhibit low coefficients of friction against steel. Many salts also exhibit the properties of solid lubricants, but most suffer from chemical sensitivity, thermal sensitivity, or other deficiencies which limit their use. Lead oxide and boron nitride lubricate well at high temperatures. However, both show undesirable higher frictions as the temperature drops.

Conditions Affecting Uses

In thin films, the relative thinness makes their use very dependent on many factors. For example, if the substrate is very hard, it backs up the film, and much lower forces are needed for motion. Similarly, the surface of the substrate is very important. If it is quite smooth, the film will adhere poorly. Thus, it is normally suggested that the substrate surface be pretreated by phosphatizing, sand-blasting or etching to allow better binding of the thin film.

Stainless steel is usually vapor-blasted for adherence of the thin film lubricants, while iron surfaces are best phosphated. Indeed, they may also be sand-blasted before phosphatizing. However, some of these pretreatments, especially the chemical ones, are sensitive to high temperatures; therefore, the desired pretreatment must be balanced against the use conditions.

Thin film lubricants are very sensitive to the atmosphere in which they are being used. Graphite will not work as a lubricant if it is heated in a vacuum; it needs an amount of absorbed gas to insure lubricating properties. This is not true of molybdenum disulphide or Teflon and nylon. On the other hand, too high humidity will lead to corrosion problems.

Naturally, load and speed are also important conditions to be watched when using thin films. Unfortunately, no generalizations are possible because each thin film lubricant is composed of different resins and different solid lubricants. Thus the properties of each thin film solid lubricant depend mainly on conditions of use and makeup of the film.

Dispersions in greases or liquids

depend greatly on the dispersing medium. This can be an oil, solvent, water, grease, silicone, or a number of other special fluids. The amount of the solid lubricant dispersed in the system, because of cost, is limited to that needed to give correct lubrication. Of course, there should be enough so that there will always be solid lubricant available.

Another very important condition is the particle size. For very thin solvents of low viscosity and for boundary conditions particles should be fine to reduce settling and constant lubrication. However, in metalworking, where the friction action actually occurs only once, particles can be larger.

Temperature, load and speed are also important. Stability is somewhat affected by high temperature. The dispersion medium must be suitable to the load and speed which are going to be occurring in the system. Each application must be reviewed by itself and the dispersing medium, dispersed solid, and properties such as viscosity and solids content must be chosen to make for the best service. There is no set answer to the question of what type of lubricant will be used for what load and what speed.

Uses of Solid Lubricants

Colloidal graphite in water was first used in wire drawing. No other lubricant is so well adapted to fine tungsten and molybdenum wire; its use enables wire to be drawn through diamond dies with a minimum of effort and a maximum die life. Colloidal graphite in oil is frequently used as an assembly lubricant for gear trains and piston engines, or compressors. A dispersion of graphite and naphtha is widely used in deep drawing magnesium and other light metals. The solvent rapidly evaporates leaving a very smooth thin film of graphite which allows the metal to flow smoothly without tearing or sticking on the die surface.

Colloidal molybdenum disulphide in petroleum oil is frequently used for extreme pressure applications and as an additive for greases. Both colloidal molybdenum disulphide and colloidal graphite are employed in special fast evaporating solvents such as isopropanol. These films provide a rapid-drying, dry film lubricant which prevents galling in

ROTOBLAST CUTS CLEANING TIME 42%



**Pangborn
Rotoblast
reduces
cleaning
time from
12-15 minutes
per 2,000 lb.
load to
7 minutes at
Ingersoll-Rand**

At Ingersoll-Rand Co., Painted Post, N. Y., blast cleaning loads weigh 2,000 lbs., include castings up to 300 lbs. each. To handle these loads efficiently, Ingersoll-Rand replaced its old blast cleaning barrel with a new Pangborn Rotoblast Barrel . . . and benefited *three* ways!

Cleaning quality is "incomparably better." Maintenance time and costs have been drastically cut. (For example, wheel vanes previously lasted 12 to 15 blast hours, now last 70 blast hours.) And cleaning time per load has been reduced from 12-15 minutes to only 7 minutes! Cleaning production now exceeds 10,000 lbs. per hour, cutting 7½-hour days to 3 and 4-hour days in the cleaning department.

For full details on how Pangborn Rotoblast can save you money, write: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment—Rotoblast Steel Shot and Grit.*®

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REFRACTORY PORCELAIN COMPANY
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Solid Lubricants . . .

press fitting and assembly operations where lubrication is needed only once.

In addition, both graphite and molybdenum disulphide are dispersed in many other unusual vehicles such as glycols, silicones, and other special organic vehicles resistant to oxygen or high temperatures. In many instances, the lubricating action is due only to the dispersed solid.

Both graphite and molybdenum disulphide are also dispersed in numerous types of resins systems. Coated on metals and then baked or air hardened, these provide a permanent solid film lubricant. They are used on nuts and bolts for assembly purposes in the aircraft industry, for business machine parts, for places where lubrication must be a one-time proposition and for places where normal fluid lubricants would be chemically unstable. Recent developments have made it possible to disperse TFE in resin solutions; this provides lubricants which are white or various colors rather than the black of molybdenum disulphide and graphite.

Some solid lubricants are used in powder form but this is probably limited. The handling of dry powders is so difficult that manufacturers prefer to deal with the bulk solid or with liquid dispersions.

C.R.W.

Hot Tears in Cast Steel

Digest of "Metallurgical Aspects of Hot-Tearing in Cast Steel", by Kurt Beckius, *Foundry Trade Journal*, Vol. 104, Jan. 30, 1958, p. 115-123; Feb. 6, 1958, p. 149-153.

RECENT STUDIES of basic hot tear mechanisms and the delineation of factors known to influence hot tearing in castings have proven of significant value. Investigation was conducted at the Royal Institute of Technology, Stockholm.

Experimentally, solidification and hot tearing characteristics of numerous specimens were studied under conditions that would quantitatively reveal the influence of composition, temperature, cooling rate, and specimen size and geometry. The basic apparatus consisted essentially of a



Lindbergh carbonitriding furnace at Western Automatic. Gulf Super-Quench is used in the internal bath.

Licks valve warpage problem, gets uniform hardness and cleaner finishes with Gulf Super-Quench

Take it from Bryan W. Miller, Heat Treat Foreman at Western Automatic Machine Screw Company, Elyria, Ohio—you can solve many of your quenching problems with Gulf Super-Quench.

"We used to have quite a warpage problem in the quenching of automotive valves made of B 1113 steel," reports Mr. Miller, "attributable to nonuniform cooling throughout each piece. But with Gulf Super-Quench we're able to hold expansion on these valves to within .003" and also maintain uniform hardness. What's

more, we get clean finishes that need no sandblasting."

What makes Gulf Super-Quench so effective? It's the dual action of fast quenching through the hardening range and slow cooling in the critical distortion range. Result: Gulf Super-Quench assures deeper and more uniform hardening, less distortion, and clean, bright work.

You too can obtain better results from many of your quenching operations with Gulf Super-Quench. For proof, just call a Gulf Sales Engineer at your nearest Gulf office.



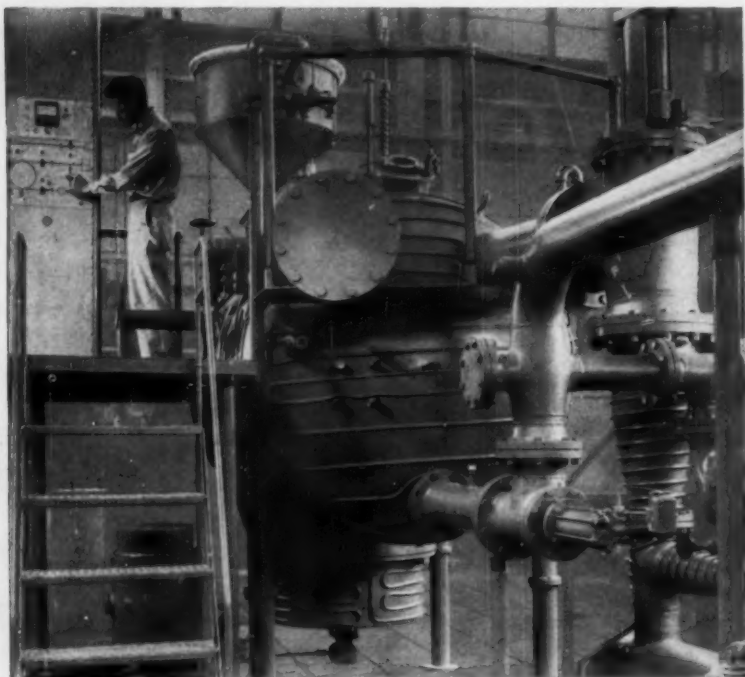
Gulf man on the job. Left, T. F. Irving, Gulf Sales Engineer; right, Bryan W. Miller, Heat Treat Foreman, Western Automatic Machine Screw Co.



GULF OIL CORPORATION

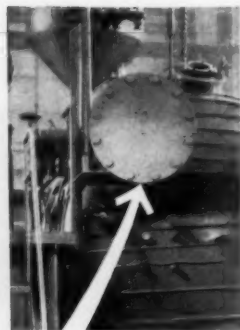
Dept. DM, Gulf Building, Pittsburgh 30, Pa.

GULF MAKES THINGS RUN BETTER!



Get started in vacuum metallurgy this sensible pay-as-you-grow way

You may never need more than the basic 50-to-200 lb. capacity of the CEC vacuum induction furnace shown above. It's ample for medium-scale melting and casting. But if your needs change, as they well may in this rapidly expanding field, you can easily increase capacity to 300 lbs. Just open the flanged nozzle (arrow, left) and add an-



CEC gives you room to grow

other pumping system. Similarly, with the CEC laboratory and pilot plant model, you can start out with 5 lb. melts, then only change crucibles to accommodate 12, 17, 30, even production-rate 50-lb. melts. Same with the big CEC large-scale production model . . . it's expandable from 300 to 1000 lbs. The capacity is there, if you want it. You pay only for what you need, when you need it.

WRITE for informative Bulletins P4-30, 32.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N.Y.

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES



Hot Tears . . .

device for measuring longitudinal contractions of a cylindrical specimen during solidification and cooling. The specimen (of a tapered design) established temperature gradients and localized hot tears. Normal contraction of the specimen was restrained by a spring-loading mechanism that initiated and accentuated hot tearing during solidification. Data were plotted in terms of time-versus-contraction curves for each of the conditions studied, and corresponding photomicrographs were then used to indicate the correlation between microstructure and hot tearing characteristics.

From his analysis of the results, the author concludes that hot tears are usually initiated just below the freshly solidified surface of the casting, and then extended both inwardly and outwardly, eventually reaching the surface. Supplementing this conclusion, the following explanation of the mechanism of hot tearing is offered. (It is noteworthy that certain aspects of the author's explanation do not agree entirely with those of previous investigators.)

When molten steel comes into contact with the wall of the mold, a very thin shell of solid steel forms and becomes continuous from one end of the specimen to the other. Due to heat loss through the walls of the mold, the shell will steadily decrease in temperature, and contract. When this contraction in the solid shell takes place freely (that is, unhindered by surface friction or external restraint), contraction will then proceed without the development of any stresses or resulting strains in the shell. On the other hand, with great surface friction, the shell will be locked at numerous points on the contact surface with all movement or contraction replaced by a uniform stress along the entire shell. In these instances hot tearing would not be expected. In the latter instance, however, stresses could be dissipated in the solidified shell by plastic deformation. Thus, as long as the shell is quite thin and there is good contact between the mold wall and the steel, such stresses and the accompanying plastic deformation may lead to hot tears in the shell. The resulting tears may then continue outwardly to the surface,

ACHESON

dispersions digest

Reporting uses for

dag
BRAND
DISPERSIONS

COLLOIDAL DISPERSIONS OF GRAPHITE,
MOLYBDENUM DISULFIDE, AND OTHER SOLIDS

'dag' and 'Prodag' are trademarks registered in the U.S. Patent Office by Acheson Industries, Inc.



'dag' 35, brush-applied to the slides of this rolover machine, increases machine life for this midwest foundry.

An expensive foundry problem was solved for the D. J. Murray Manufacturing Company, Wausau, Wisconsin, with the use of Acheson's 'dag' 35 — colloidal graphite in an alkyl resin solution. Slides on the huge rolover machine installed in their foundry division, previously lubricated by first a dry graphite and then rosin, were becoming deeply scored as a result of its 90-cycle-a-day operation in the handling of bench and floor molds.

MUELLER BRASS SAVES \$15,000 A YEAR ON FORGING LUBRICATION

Efficiencies realized by just one company — with the help of Acheson Dispersions — have already added up to this substantial savings. Uniform coverage, easy sprayability, and lasting lubrication effectiveness are providing this leading forgings producer: longer die life, increased production, fewer rejects, and improved forgings. This lubricating success story is being repeated throughout the metal working industry. Possibly you could profit from the use of an Acheson Dispersion.

'Prodag' application on forging presses at Mueller Brass Company has saved between \$15,000 and \$17,000 annually for the past fifteen years. These impressive savings earned by this Port Huron, Michigan company — the world's largest producer of brass and bronze forgings — have been realized in many areas.

Previously, crank forging pressmen at Mueller swabbed the dies between each press stroke. Mueller designed their own spray apparatus, both manual and automatic, to lubricate lower and upper dies simultaneously. Time studies have shown that spraying has effected a five percent-per-pound economy over the swab method.



Spray application of 'Prodag' at Mueller Brass Company has resulted in impressive production savings.

The scoring and machine vibration was so severe that according to Maintenance Foreman, Ben Sayles, "we could see that the life of the machine was going to be very short if we continued this method of lubrication." Coating the slides daily with 'dag' 35, improved machine operation immediately. The scoring all but disappeared. After two years of application with this Acheson dispersion, no repairs have been necessary and none are foreseen. Since the entire production of their grey iron sand slinger line — some 60 tons of material in 8 hours — goes through this machine, the downtime avoided represents an important savings to the company.

For additional information, write for Acheson Bulletin No. 425. Address Dept. MP-99.

Even more importantly, by using Acheson's 'Prodag' — a dispersion of graphite and water — diluted 1:35, Mueller has gained longer die life, reduced the percentage of scrap loss, and has obtained a better finish on their forgings. According to Mr. O. M. Hanton, Chief Forging Engineer for Mueller, "with 'Prodag' we get the right amount of lubricant on the die. Swabbing resulted in too much lubrication at one place or another in the die cavity, resulting in either a ruptured die or a defective part. Previously, every forging produced had to go to the grinding department. And grinding is one of the most expensive operations in a forge shop."

In producing deep-cavity forgings, or products which demand much smaller tolerances, Mueller uses 'dag' No. 3 — another of Acheson's graphite-water base dispersions. If you have a forging lubrication problem it will pay you to call in your Acheson Service Engineer or write for Bulletin No. 426.



ACHESON Colloids Company

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Hot Tears . . .

but they do not always do so. The governing factors are the ductility of the shell and the magnitude of the resistance to contraction. If the resistance to contraction is overcome at a certain shell thickness, the tearing then ceases.

If, as in the present experiments,

the contraction is restrained by the resistance of a spring, the force of friction will be augmented by a force directly proportional to the contraction thus leading to more active tear formation and giving rise to ruptures at numerous points of weakness.

In a columnar or dendritic structure, tears once formed expand very readily between the dendrites since the latter grow in straight parallel

planes. Thus the structure offers little resistance to tearing, resulting in a practically simultaneous splitting over the entire periphery of the specimen. In a fine, equiaxed grain structure, hot tears will develop only at certain points where the crystal orientation is favorable in relation to direction of tensile stress. Thus, when a tear meets a less favorable crystal direction, it usually stops growing and a new tear forms at a more favorable point. This results in numerous minute tears rather than in gross splitting or fracture.

In his closing statement, the author acknowledges that conditions in the foundry are naturally more complicated than those encountered in the laboratory. However, the basic mechanism of tearing in actual castings should be the same, although the extent of tearing would depend upon the degree of localization of temperature gradients and on the amount of resistance to contraction. To avoid hot tears in practice, it is naturally important to choose a design of casting, mold material, and gating and rising system such that tear producing stresses are minimized or eliminated. If this is not feasible, the risk of hot tears can be further minimized by a suitable choice of steel composition and de-oxidation practice.

W. W. Austin

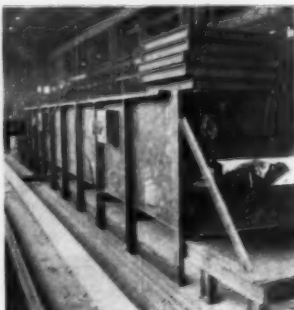


Sunbeam IS PEOPLE

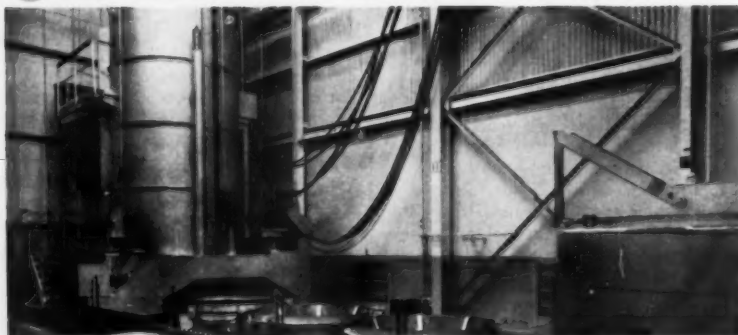
From advanced research and development to modern production; installation and servicing of countless types of furnaces and generator equipment, Sunbeam is people. Here is a closely integrated group of project and design engineers, installation and service specialists, ready to meet any challenge for the creation of industrial furnace equipment for all industry.

Sunbeam IS FACILITIES

To assist this outstanding organization of skilled and experienced people, Sunbeam has invested hundreds of thousands of dollars in cost saving production methods and equipment. Sunbeam facilities include: A complete acetylene generating plant; a specially equipped test and development laboratory shop; six large bridge cranes; a railroad spur inside the plant for convenient loading and handling; and over 120,000 square feet of manufacturing space.



Sunbeam IS CAPACITY



Traveling gantry furnace for heat treating missile parts.

At Sunbeam, versatility is the key to tremendous capacity in advanced heat treating technology. Here are human resources, plus modern facilities, plus tremendous experience accumulated over the past sixty years. Here is capacity to design, build and install complete furnace equipment that can provide profitable advantages in producing your product. Make Sunbeam your first source for furnace equipment.



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194 Mercer Street
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Abrasive Belt Grinding of Zirconium Sheet

Digest of "Surfacing of Zirconium Alloy Sheet by Abrasive Belt Grinding", by H. N. Dyer and R. A. Leggett, Behr-Manning Co., Troy, N.Y.

BONDING ZIRCONIUM SHEETS together is an important step in the fabrication of fuel elements for atomic reactors. Preliminary preparation of the sheets — they are used to clad the fuel elements — must yield flat uncontaminated surfaces, otherwise the gas-bonding process will not effectively unite them with a good metallurgical bond. The best bonds are obtained from sheets which have been roughened uniformly and are free of embedded grit and chemical contaminants. Abrasive belt grinding can do the job effectively and economically.

The authors investigated the ef-

Casting research on 17-4PH increases elongation 10% . . . costs Cannon-Muskegon customers nothing ¶

Cannon-Muskegon research has developed certain procedures for investment casting of 17-4PH that assure, consistently, the high level of properties which this alloy is capable of producing. ¶ Casting test bars in a keel block arrangement as shown here—rather than an end-gated arrangement—is one of them. Special recommendations on aging time and temperature are another. ¶ Further, Cannon-Muskegon research has demonstrated the necessity of stricter limits to provide a balanced chemistry and prevent harmful effects induced by too high or too low a content of certain elements. Keeping within these limits and following Cannon-Muskegon recommendations assures investment casters of consistently obtaining optimum performance from this fine alloy. ¶ We invite you to write for a free copy of the ICI Technical Research Report, "The Effect of Aging Time and Temperature on the Mechanical Properties of Investment Cast 17-4PH."



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Belt Grinding . . .

fects of abrasive belt speed, type of grinding fluid, and type and size of abrasive grain on bonding qualities of reactor-grade Zircaloy-2 (hot and cold rolled). Bonding was accomplished by sealing surface-ground sheets in a protective container from which air had been evacuated. The assembly was then heated at 1550° F. in a helium atmosphere at 10,000 psi. Mating sheets bond by diffusion and grain growth.

For this investigation, the Zircaloy sheets were ground with aluminum oxide and silicon carbide belts running on an X-serrated, 80 durometer rubber contact roll. Belt speed varied from 1100 to 5500 ft. per min. and two grinding lubricants (tap water and a heavy sulphur-chlorinated cutting oil) were tried. Feeding rate of the sheets through the grinder was maintained at 4 ft. per min.

Surfaces abraded with 60-grit silicon carbide belts, run at 1500 to 3000 ft. per min. with a sulphur-chlorinated grinding oil, produced the best bonds. The total amount of metal removal is not critical except, of course, a new surface must be exposed by the operation. Good bonds are obtained from both hot and cold rolled Zircaloy (see Fig. 1). None of them could be broken when peel

tested (driving a chisel into a V-notch at the interface). Twelve out of thirteen bonds did not corrode during exposure to steam at 750° F. for one week.

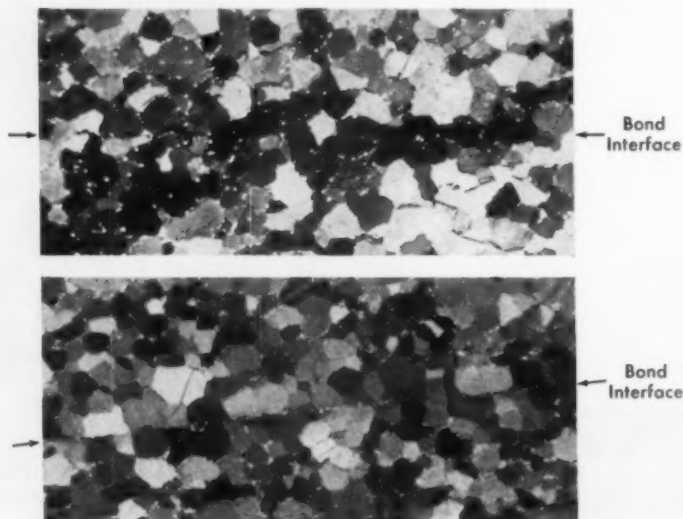
While grinding zirconium, an extremely hot, intense spark is produced, and fire-prevention measures are necessary when oil-base lubricants are used. Low belt speed, a heavy flood of oil (flash point above 350° F.), and an efficient filter to remove chips from the lubricant are recommended. R.G.D.

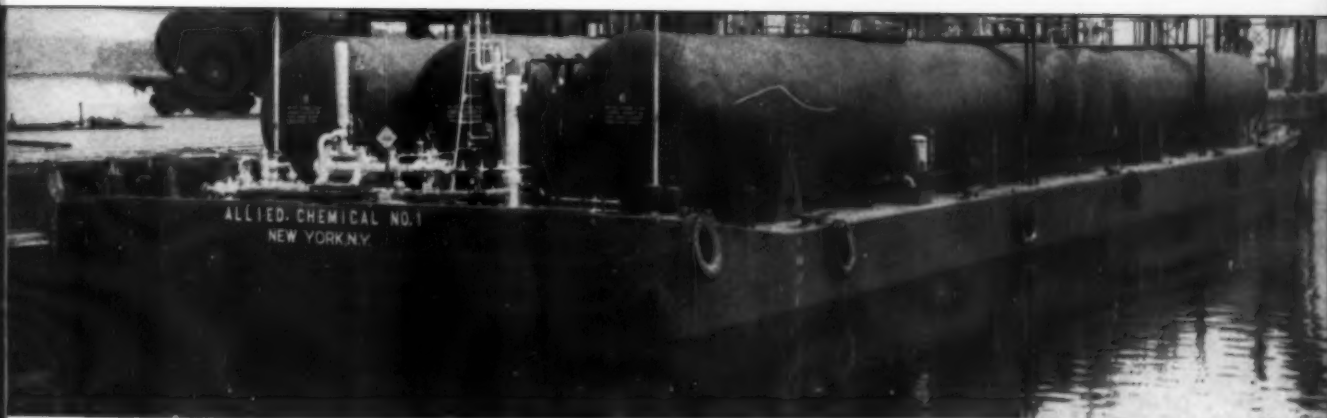
Hot Forming Magnesium Alloys

Digest of "Hot Forming Assembling and Service Applications of Magnesium Alloys", by R. G. Wilkinson, *Journal, Institution of Production Engineers*, Vol. 36, April 1957, p. 224-237.

THIS PAPER presents a broad but brief survey of shop fabricating practices and applications in British and American aircraft industries. Less than 10% of the magnesium used in the United Kingdom has been in the form of wrought materials, while in the United States the proportion has been around 30% and even as high as 50% in 1950. Illustrations of typical magnesium applications taken from American sources

Fig. 1 — Photomicrographs Show Influence of Prior Treatment on Bond Quality Obtained From Gas-Pressure Bonding of Zircaloy-2 Sheets. Top — typical bond between belt-abraded sheets (hot or cold rolled); bottom — poor bond between vapor-blasted and pickled sheets. Both photomicrographs taken in polarized light. 250×





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Hot Forming . . .

are the use of 7500 lb. of magnesium sheet in the B-36 by adhesive bonding, the tail cone assembly of the B-47, and the all-magnesium F-80 airplane.

The advantages of hot forming magnesium are:

1. More severe deformation is possible.

2. Reduced springback gives better dimensional accuracy of parts.

3. Smaller press capacity is obtained because power requirements are reduced.

4. Dimensional control of parts by regulation of tool and parts temperature is often possible.

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Forming tools must withstand temperatures up to 600° F. Magnesium alloy tools can be used for small production runs. Other tool materials are mild steels, toolsteels, chromium-plated or nitrided steels, plain or Meehanite cast iron, aluminum, Kirksite, antimonial lead, concrete and plaster protected with glass-fibre cloth.

Graphitic lubricants are used for severe forming while waxes and high-temperature oils are used for mild forming. The latter are more easily removed from formed parts than graphite.

A good deal of hand forming is done in the United Kingdom because of lack of large quantity production. Consequently, the description of the forming methods, such as deep drawing, hammer forming, stretch forming and spinning, seem to be based largely on American practices. In bending, the British alloys possess a minimum 90° cold bend radius of 5 T, but 10 T (bend radius based on material thickness) is more usual. For hot working, these became 1 T and 4 T, respectively.

Single draws to a depth three to four times that for cold steel or aluminum can be made.

Surface Protection and Assembly

Protective treatments and finishes introduced recently in the United States are the anodic treatments HAE and CR-22, developed by Frankford Arsenal, and the Dow No. 17, developed by the Dow Chemical Co. In the United Kingdom they are the fluoride anodizing and surface sealing treatments. In the latter, the epoxy resin Araldite 985 E is applied over the anodized and chromated surface.

Protection against bimetallic corrosion in assemblies is obtained by the use of insulating strips, washers, chromate-containing sealers, and cadmium-plated steel screws or bolts. (Recent American developments indicate that tin-plated screws and bolts are more effective.) Protection in riveted assemblies is obtained by use of L 58 (95% Al, 5% Mg) or L 57 (duralumin) aluminum alloy rivets dipped in protective com-



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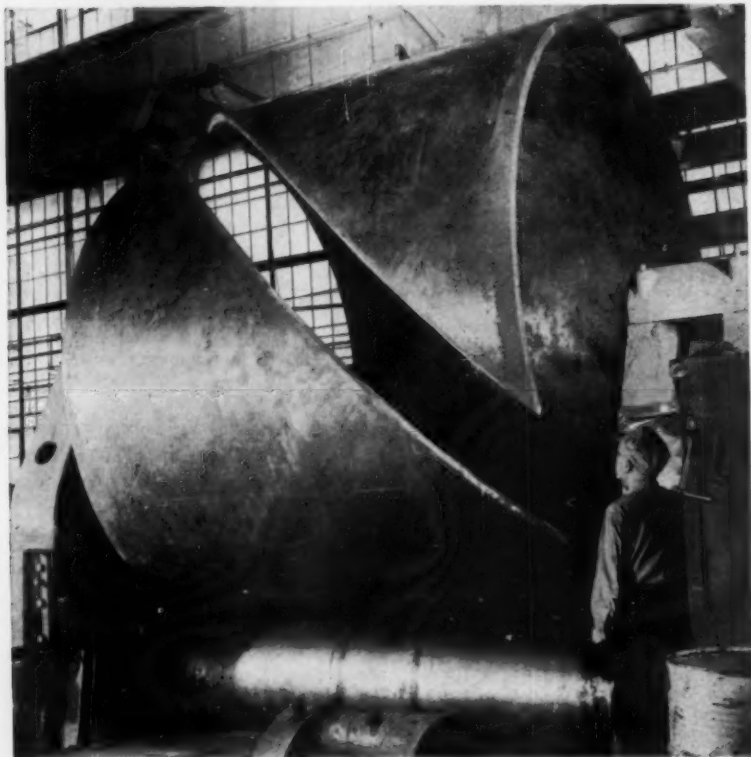
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Hot Forming . . .

pounds. Riveting procedures are summarized in some detail.

The good weldability of nearly all the highest strength magnesium alloys is advantageous in fabrication of many parts. Typical British and American welded parts are illustrated. Spot welding is used extensively in America but sparingly in the United Kingdom. Adhesive bonding with Metlbond on some B-36 assemblies in America was cited and with Redux or Araldite resins in the United Kingdom.

C. E. NELSON

Spark Deposition

Digest of "And Now, Spark Deposition!", *Metalworking Production*, Vol. 102, March 28, 1958, p. 554-555.

THE MACHINING of many of the newer materials, particularly those developed for high-temperature applications, requires that the qualities of several types of cutting tools be combined into one. The Nimonics, for example, require tools with the wear resistance and hardness of carbides plus the toughness of high speed steels.

A recent machine developed by Impregnated Diamond Products Ltd., Gloucester, England, produces the desired combination of qualities. This machine utilizes the transfer phenomenon that takes place in spark erosion to deposit tungsten carbide on the wear surface of tool materials. The process is essentially as follows:

The tool is ground, degreased and set in a tool holder. An electrode of the desired material is positioned in close proximity to the tool and the current is turned on. A spark discharge takes place across the air gap and the electrode traverses the area to be surfaced. This results in a deposit of the electrode material on the tool surface which is harder than the base metal. At the same time, further hardening of the tool surface takes place. This treatment is normally applied to the surface which is subject to the greatest wear, although other surfaces may also be treated if desired. Tools thus treated exhibit a substantial increase in service life.

B. TROCK

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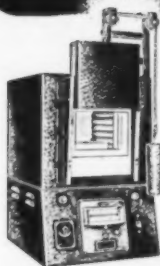
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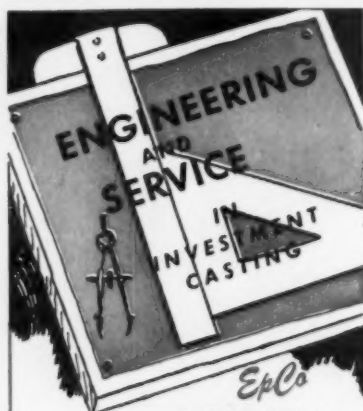
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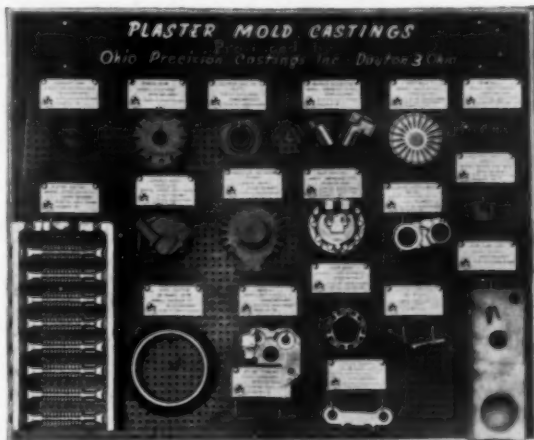
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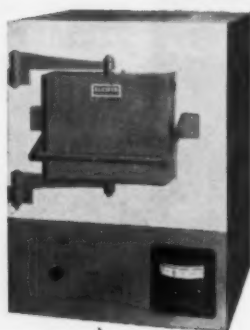
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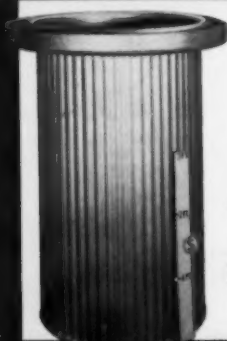
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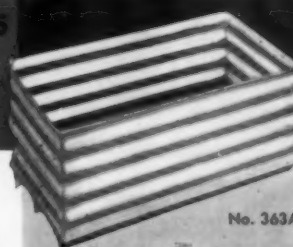
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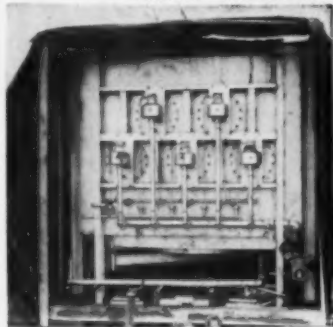


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Write for Bulletin 658.



Saturable Reactor
with tap changing transformer

Also a complete line of
dry-type transformers.

All standard and intermediate ratings,
¼ Kva to 10,000 Kva,
120 to 15,000 volts.

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Sorgel Electric Company

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Over 40 years of electrical manufacturing
development

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Low Cost Analysis HIGH TEMPERATURE ALLOYS

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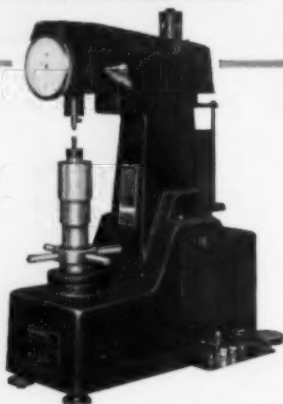
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Wilson Mechanical
Instrument Division

American Chain & Cable
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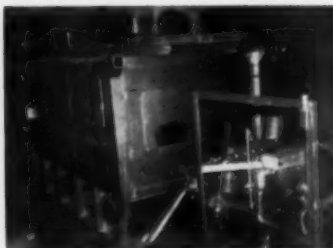
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GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!

SACRIFICE BEFORE MOVING!
4 Brand New Twin-Muffle Furnaces
for Sintering, Brazing, or Bright
Annealing.



Pusher Type. Globar

Heated. 440 v./3 phase/60c.

Capacity: 120 KW to 200 KW

Work Dimension of each: Muffle: Width 14" to 18", Length 8' to 15', Height, 6" to 10".

All complete with W.J. cooling sections, transformers, switches, atmosphere generators, Electrodryers, panels with Micromax recorders and controllers.

Also in stock for immediate delivery: New blowers, alloy trays and baskets, burners, solenoid valves, thermocouples, etc.

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ULTRASONIC INSPECTION SERVICE

A COMPLETE SERVICE PROVIDING
DAY TO DAY ULTRASONIC TESTING
FOR THE DETECTION OF FLAWS IN
MATERIALS.

FIELD TESTING SERVICE LABORATORY TESTING SERVICE

CONDUCTED BY SPERRY ENGINEERS
LOCATED THROUGHOUT THE
COUNTRY.

Descriptive literature available.



Sperry Products, Inc.

DANBURY, CONNECTICUT

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HARDNESS TESTING SHORE SCLEROSCOPE

**Pioneer American
Standard Since
1907**



Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

**OVER 40,000
IN USE**

SHORE INSTRUMENT & MFG. CO., INC.
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LIST NO. 133 ON INFO-COUPON PAGE 171



SOUTHWESTERN METAL EXPOSITION

May 9 to 13, 1960

Automobile Building
State Fair Park
Dallas, Texas

Floor plans available for third Southwestern exposition selling to industry in Texas, Oklahoma, Louisiana, New Mexico, Colorado, Arizona, California and neighboring states.

For a copy of the floor plans or other information about this important METAL EXPOSITION in a section of the country where industry is growing most rapidly, write . . .

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Eclipse PRESSED STEEL POTS

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FIND CRACKS QUICK!



Use
Spotcheck

"SPRAY-ON"
Dye Penetrant
Inspection

**QUICK TEST
ENDS VISUAL
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SPOTCHECK finds cracks, porosity, and leaks you can't see (any defect open to the surface). SPOTCHECK—marks them with a brilliant red warning. Users report speedy, money-saving results. SPOTCHECK is used to inspect metals, carbides, ceramics, plastics, etc. Multi-use SPOTCHECK can simplify your maintenance and in-progress inspections. SPOTCHECK'S complete SK-3 kit is portable; no other equipment needed!

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Company _____
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METAL PROGRESS

Solve Inspection Sorting Demagnetizing Problems

with
MAGNETIC ANALYSIS...

MULTI-METHOD EQUIPMENT

Electronic equipment for non-destructive production inspection of steel bars, wire rod, and tubing. Detects mechanical faults and variations in composition and physical properties. Average inspection speed—120 ft. per minute.

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An eddy current tester with six inspection methods operating simultaneously—for high-speed, non-destructive testing of non-ferrous and non-magnetic tubing, bars and wire from 1/8" to 3" diameter. Detects both surface and sub-surface flaws, and variations in chemical, physical and metallurgical properties at speeds of 200 to 600 ft./min.

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Electronic equipment for inspecting ferromagnetic wire ropes from 1/32" to 3" diameter. Detects broken, cross-over or missing wires, plus defective welds and deformations at production speeds up to several hundred feet per minute.

COMPARATORS AND METAL TESTERS

Electronic instruments for production sorting of both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

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Electrical equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.



"THE TEST TELLS"

For Details Write:

MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

LIST NO. 51 ON INFO-COUPON PAGE 171

TENSILKUT

Pat. Pend., U.S., Canada



How with TENSILKUT, whatever your testing methods or materials, you can have perfect precision machined physical test specimens in less than two minutes.

TENSILKUT precision machines all foil, film, sheet and plate metals . . . from .0005" foil to .500" plate. Hard 201 stainless steel foil to soft 1/2" aluminum, soft plastic film 1 mil in thickness or the abrasive glass ionomates in .500" plate, are machined with specimen configurations accurate to $\pm .0005"$. Machined edges are completely free of cold working or heat distortion and require no hand finishing.

TENSILKUT table and floor models are available with motors from 1/2 to 2 1/2 h.p. Write for free brochure.

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Danbury Industrial Park, Danbury, Connecticut

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**Measures Nonmagnetic
Coatings with
 $\pm 5\% \pm .0001"$ accuracy**



**NEW
pocket-size
Thickness
Gauge**

ELCOMETER measures thickness of porcelain enamel, paints, platings, foils, glass, paper, plastics, and other nonmagnetic coatings quickly and accurately. Gauges flat or curved surfaces and hard-to-get-at spots easily. Needle locking device assures correct reading every time. Complete with tough leather case, containing inner pocket for test strips, and carrying harness. Weighs only 6 oz.

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**ONLY
\$78.75**



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HARDNESS TESTING MACHINES
made by the Alpha Co. of
Sweden and available from
our stock at New Rochelle

Never approached in
ACCURACY AND
CONSTANCY of cali-
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standard 3000kg test
load . . . maximum
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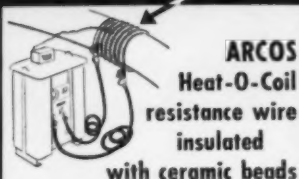
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GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N. Y.

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NEW IDEA
for preheating and
stress relieving



• Low cost • Easy to apply • Ideal
for field use • Uses standard welding
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Metals for Supersonic Aircraft and Missiles



**New ASM Book based on
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Metals for Aerodynamic
Applications sponsored by
the American Society for
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This is a book for the *designer*
and the *metallurgist* who
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- protective metallic coatings
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metallurgy and design, fab-
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Automatic, direct-reading
two-color pyrometer

2610°F

For flowing, moving or
stationary objects

SHAW INSTRUMENT CORPORATION

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gives detailed in-
formation on
this unique in-
strument.



NEW ULTRASONIC FLAW DETECTOR . . .

SONORAY MODEL 5

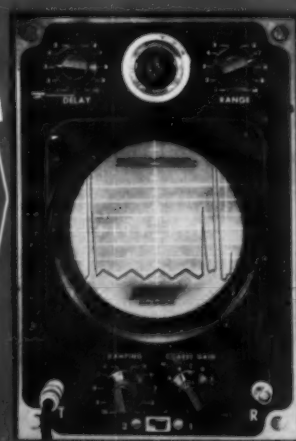
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at 2.25 mc. **resolution:** clearly resolves
a 1/8" flat 1/8" below surface at 2.25 mc.
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between 2.4 mc and 10.0 mc.

PORTABILITY: 7 1/2" x 11" x 20 1/4" — 33 lbs.

PRICE: complete, ready to use, including
transducer — \$2,750. Plug-In Flow
Alarm (optional) — \$225.

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BROWN HOUSE ROAD, STAMFORD, CONN. Specializing in Ultrasonics since 1946



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low temperature equipment

to
140°
below
zero

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- shrink fits
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- precision tools
- laboratory testing

1.5 and 6.5 cu. ft. capacities. Sturdy, all-steel cabinet construction. Sublids for constant inside temperature. Adjustable temperature controls. Special accessories available.

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PREGRINDS
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POLISHES
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Simultaneously!



Write for literature describing this and other modern metallographic specimen preparation apparatus

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- DEGREASERS • AGITATING WASHERS • PICKLERS
- PHOSPHATIZING WASHERS • ALKALINE WASHERS
- FLOW COATING SYSTEMS • "SPOTLESS" DRYERS
- OVENS • ULTRASONIC CLEANING EQUIPMENT

We will be happy to send a sales engineer to help you with any metal cleaning equipment problem. Complete information on request.

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CIRCO

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...over any surface!



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Specialists in Processing Carriers Since 1932.

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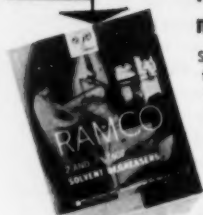
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METAL PROGRESS

**Q
A**

METAL PARTS CLEANING? PROBLEMS?

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new **BULLETIN!**



Send for your copy of the Ramco Bulletin. See how Ramco 2- and 3-dip degreasers can solve your metal parts cleaning problems, economically, efficiently, safely!

Write today!

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DIV. OF RANDALL MFG. CO., INC.

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independent
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PLATE & SHEET .002" to 3" thick

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HARDNESS

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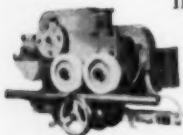
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Steel stamps, dies and
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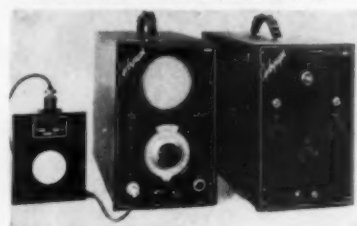
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. . . for unscrambling
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and READ

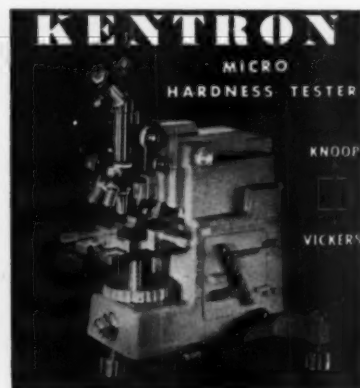
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Applies 1 to 10,000 gram loads

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Kent Cliff Laboratories Div.

The Torsion Balance Company
CLIFTON NEW JERSEY

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RUST-LICK IN AQUEOUS SYSTEMS

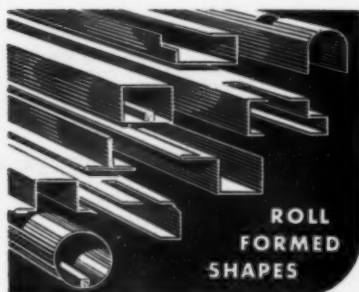
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with transformer

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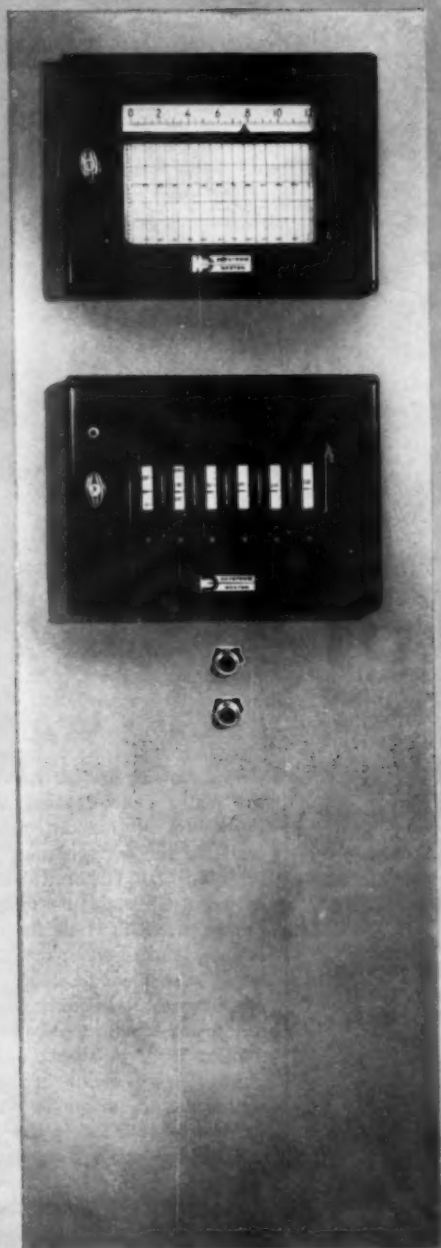
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New Welding Processes

Digest of "Prediction in New Metal Joining Processes", by John J. Chyle. Paper presented at the Society of Automotive Engineers National Aeronautical Meeting, New York, March 31, 1959.

IN A TABULATION of metal joining processes other than mechanical joints or adhesive bonding, the author lists 15 kinds of pressure welding, 12 kinds of fusion welding and 10 methods of brazing, plus 20 variants related to heat source or protective atmosphere, a total of 57. Some of them of course are not new; others have been described at more or less length in recent issues of *Metal Progress*.

Pressure Welding—For example, for ultrasonic welding, see J. Byron Jones, *Metal Progress*, April 1958, p. 68. Mr. Chyle notes its present limitations to spot or seam welds in foil or thin sheet (± 0.10 in.) but believes thicker material can be handled.

In high-frequency resistance welding (W. C. Rudd, *Metal Progress*, May 1958, p. 82), 100,000-cycle current is so directed as to concentrate heat at the very bottom of a sharp "V" where the edges of the joint slightly diverge. It is very fast and the heat-affected zone is of minimum volume.

Foil seam welding is for butt welding flat sheet. As the joint moves between rotating disk electrodes, thin ribbons of the same metal are also fed on top and bottom. Fusion starts at the middle of the plates some distance ahead of the center of pressure, rapidly extends to the surfaces and incorporates the foil or ribbon. The squeeze between electrodes is sufficient to pressure-weld the foil into a smooth surface, smooth enough so it seldom needs subsequent finishing. To this advantage is added dimensional uniformity and high speed (24 in. per min. on 0.087 in. sheet).

An improvement in resistance welding uses magnetic forces to synchronize accurately the pressure and welding current in, say, a spot welder. So time is reduced to as low as half a cycle, and is especially adaptable to metals of high conductivity.

Friction welding was described by Arthur Tesmen in his article on

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Welding . . .

Russian developments in *Metal Progress* for January 1959 (p. 79). Mr. Chyle notes it is limited to cylindrical parts, but it apparently requires comparatively little power.

In thermopressure welding and diffusion bonding, cleaned flat surfaces are pressed together at moderate heat long enough for transfer of atoms across the interface and the formation of new crystals or intermetallic compounds (if the parts being joined are dissimilar). Pressures may run up to 10,000 psi., temperatures are generally below 1000° F. and times may range from 20 min. to 3 hr. The low tempera-

tures may not alter properties acquired by previous heat treatments; distortion also is prevented.

Fusion Welding — The electrosag process was described in Mr. Tesmen's article cited above. Mr. Chyle lists as an important advantage the high rate of metal deposition — as high as 45 lb. per hr. — and mentions as disadvantages the large heat-affected areas adjoining the weld and the coarse columnar crystals in the weld itself. Its future seems to be in joining very thick plates and building up massive layers on large surface.

Electron beam welding (see *Metal Progress*, May 1958, p. 65) uses an electron beam to melt adjoining metals with or without filler wire

and is possible only in very high vacuums — below 2×10^{-4} mm. of Hg — not contaminated from any impurities in any electrode. It is also confined to assemblies small enough to be placed in available vacuum chambers.

Arc plasma is somewhat similar to the above. An umbrella-shaped arc is struck between a central electrode and a surrounding nozzle — both water cooled — and argon or helium forced through the annulus. The heat of the arc dissociates the gas molecules into ionized atoms and a stream of this "plasma" at 10,000 to 30,000° F. issues from the torch. This temperature is high enough to serve as a welding blow-pipe for the most refractory metals and even to spray-coat refractory oxides.

Brazing — Mr. Chyle confined most of his remarks on this subdivision to the methods used for making sandwich constructions for the aircraft and missile industry. For details of this see *Metal Progress*, October 1958, p. 110. Many variants exist in the nature of brazing compounds and in the methods of heating. The latter may vary from conduction from heated dies, heating in suitable envelope prior to pressure in a separate furnace, radiant energy from high-intensity quartz lamps, and brazing metals incorporated in exothermic compounds or mixtures. The author believes there is a large future ahead for this process in all parts where a combination of strength, rigidity and light weight is desirable.

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Low-Temperature Transverse Impact Test

Digest of "Effect of Phosphorus and Sulphur Content on Ductility and Toughness of Cast Low-Alloy Steels", by John Zotos. Paper presented at the A.I.M.E. Electric Furnace Conference, Detroit, December, 1958.

A STUDY of the data indicates that the ductility and impact resistance of the steel tested were definitely improved by reduced sulphur and that for the best results the maximum sulphur should be 0.010%. It is difficult to reach the same conclu-

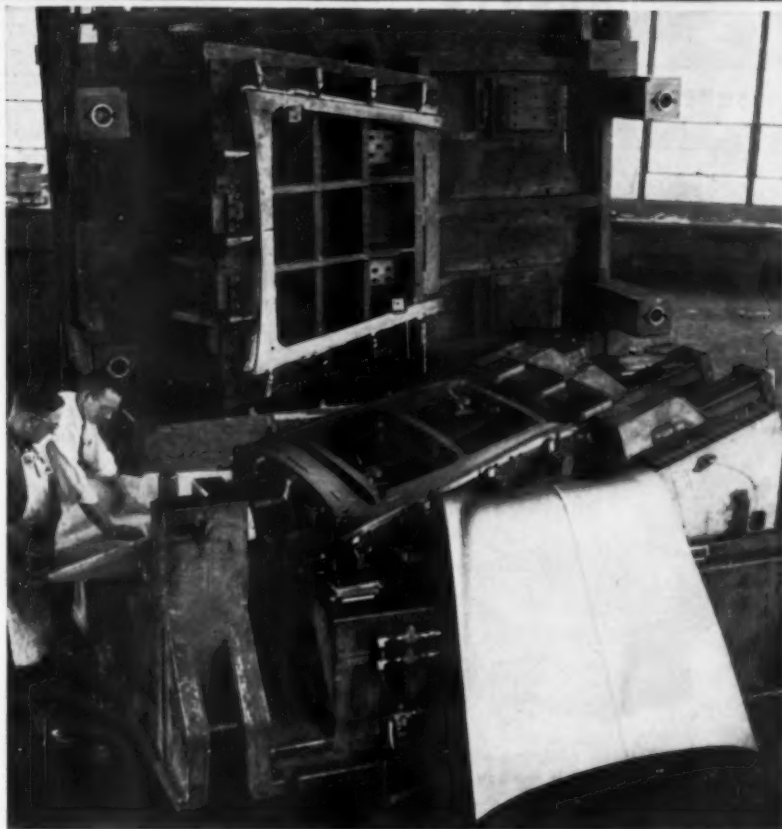


Tool Steel Topics



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Automotive Die, in 101 Sections, Made from Water-Hardening Steel

This huge die, made up of Bethlehem W-1 carbon water-hardening tool steel, trims an automobile hood. Made from tool steel furnished by Peninsular Steel Co., Detroit, the die was photographed recently at Republic Die & Tool Company, Wayne, Mich. It contains 44 composite sections, 34 wear plates, and 23 solid sections.

Bethlehem carbon water-hardening steels were selected for this exacting application because of their good wear-resistance, easy machinability, and simple heat-treatment—plus ease of welding should repair become necessary.

Bethlehem carbon water-hardening tool steels, because of their carefully controlled hardenability, provide economical service in applications calling for high shock-resistance. And with their highly selective carbon range, they have good resistance to wear, plus the toughness to withstand cold battering.

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*Here's How to
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High-precision gages, commonly made of BTR tool steel (AISI Type 01), need a stabilization treatment if they are to maintain their accuracy for years. Otherwise expansion will eventually change dimensions outside of the permissible tolerance. These dimensional changes are in a magnitude of hundred-thousandths of an inch per inch, or smaller. Insignificant on ordinary tooling, they are important on precision gages.

The expansion which occurs over a period of time is due to the transformation of austenite retained during the quench for hardening. The object of the stabilization treatments is to transform the retained austenite during the treatment, so that none remains which could transform later on. This condition exists in all tool steel grades which can be hardened to Rockwell C 60 or higher.

The most common method for stabilizing high-precision BTR gages is:

1. Quench and temper in the normal manner to produce the desired hardness.
2. Rough grind.
3. Subzero cool to minus 100/120 F in refrigerator or dry ice.
4. Warm to room temperature and then retemper at original temperature.
5. Finish grind to size.
6. Repeat cycles of subzero cool followed by tempering five more times.
7. Lap or superfinish to size.

Sometimes it is possible to shorten this procedure, particularly if the design is such that there is little hazard of cracking. For example, the tools can be subzero cooled directly from the quench, with no interval at room temperature, followed by tempering and grinding. This will permit stabilization with only two additional cycles of subzero cool plus temper, but the disadvantage is that cracking may occur after quenching.

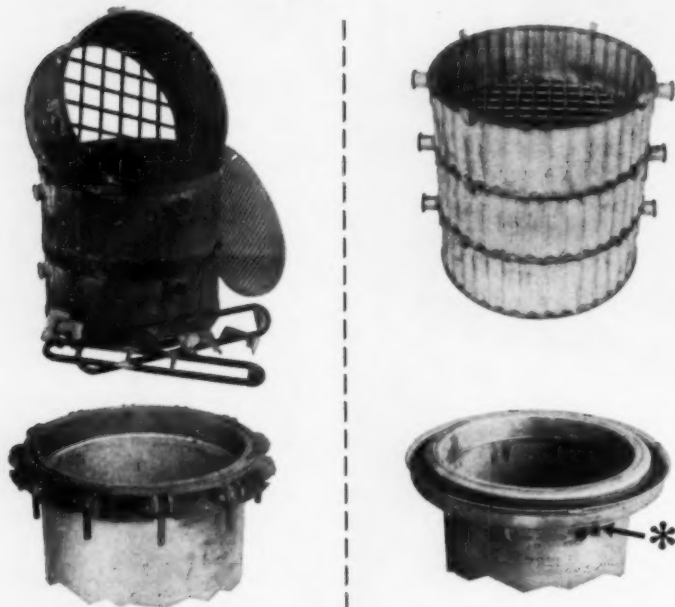
It is also possible to shorten the stabilization by cooling to minus 314 F in liquid air. This permits reducing the cycles of subzero cool plus temper to three instead of six.

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Impact Test . . .

sion for phosphorus. The effect of the type of sulphide or the residual oxygen on the low-temperature transverse impact properties is not discussed. For best results every possible step should be taken to avoid Type II sulphides in the inter-crystalline as-cast grain boundaries.

We reached the same conclusion a long time ago, while producing ingots for British gun forgings. To achieve maximum low-temperature transverse impact results, we not only had to keep the sulphur below 0.010%, but avoid the use of aluminum for grain size control, because of the degree of deoxidation promoted by aluminum and its effect on the type of sulphide in the ingots. This was probably aggravated by the large ingots cast and would not have nearly as much effect in the castings turned out by the usual steel foundry. In my opinion some interesting research could be carried out to determine accurately the effect of residual oxygen content of a heat of steel on the sulphide type and low-temperature toughness and ductility of the final casting. I believe that a comparison of silicon-killed acid and basic cast structures with aluminum-killed (fine-grained) acid and basic castings would produce interesting results.

The value of the impact test for comparing some basic properties in heats of high-strength steels is again demonstrated. Perhaps we should develop this test to encourage its use, universally, for appraising such steels.

With a routine calcium carbide-type slag and given arc furnace practice, it took hours to complete a reaction which, as demonstrated by Perrine and others, should require only a few seconds to complete under perfect conditions. This reaction time is extended because, under the conditions usually existing in the arc furnace with a proper alkaline slag, the sulphur is removed almost instantaneously at the contact surface between slag and bath; much time is required to obtain the diffusion of the sulphur at all points in the relatively deep and dead bath of steel to the point of high chemical activity at the slag line. To remove sulphur quickly from a steel bath by means of a surface slag, some means

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Impact Test . . .

of reducing the diffusion time is needed. This calls for a turbulent bath of the proper temperature. Such a development might lead to a rotating kiln type of furnace with the bath consisting of a mere sheet of highly turbulent metal which is carried through the kiln at high speed under a thin layer of slag held in contact with the bath by centrifugal action.

This points the way for some real development in steelmaking and with the work of Perrine always in mind we should perhaps build special equipment to provide greatly

increased contact of slag and highly turbulent fluid metal so that the sulphur is reduced as close as possible to zero before the steel is added to the arc furnace.

Work has already been done in this area and if the thinking applied to the sulphur reaction is directed to all the steel bath reactions, it should be easy to develop a procedure that will go all the way with hot metal as the major charge used in the electric furnace or openhearth furnace.

This well-written paper by Mr. Zotos provides some interesting data which should serve as a good guide to anyone interested in the development of high-strength steel in any

form with especially good ductility and toughness as indicated by the low-temperature transverse impact test.

H. W. McQUAID

Fabrication of Molybdenum Sheet

Digest of "The Development of Refractory Sheet Metal Structures", by Alan V. Levy and Saul E. Bramer. Paper presented before the Society of Automotive Engineers National Aeronautical Meeting, New York, March 31, 1959.

THIS DOCUMENT is a rather complete description of methods used by Marquardt Aircraft Co. to make such things as nose cones, tubes, cups and brackets from molybdenum sheet. (The usual alloy contains 0.5% Ti; its properties have been described in *Metal Progress*, June 1956, p. 72, and July 1956, p. 103). Although the alloy is formed while hot, its strength in service is due primarily to prior "cold" work, so fabrication temperatures must not cause recrystallization—that is, must be less than 2300° F. Articles made from it are suitable for low-load, short-time, high-temperature (2400 to 3000° F.) service, such as atmospheric re-entry of missiles at hypersonic speeds.

The authors report their experiences with over 60 heats of sheet in 0.01 to 0.08-in. gages, and sizes up to 36 × 60 in. Physical properties, chemical analysis, flatness (after surface grinding 0.003 in.), formability and weldability have markedly improved in uniformity. Other characteristics of the sheet now available are not so favorable.

Transition temperature is 300 to 500° F., and that means the sheet is very brittle at room temperature. Cracks often occur during normal handling. Surface grinding helps.

Sometimes a sheet is so badly laminated that it is actually separated into two sheets over large areas. This is due to the present limitations in the rolling mills; temperature is below 2300° F., less than half the melting point, and this introduces large shear stresses along the flat grain boundaries. It is possible that this will be corrected if hot mill equipment can be built for rolling at much higher temperatures.

Now and then a heat of sheet is

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4. Positive Relief Blade Lift

On the return stroke, positive relief lift raises the blade to provide proper and "cushioned" load-in on the next cutting stroke. This prolongs blade sharpness, life and accuracy.



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Catalog C85 has complete details, facts and figures on both Marvel metal cutting Hack Saws and Band Saws. Write for it today.



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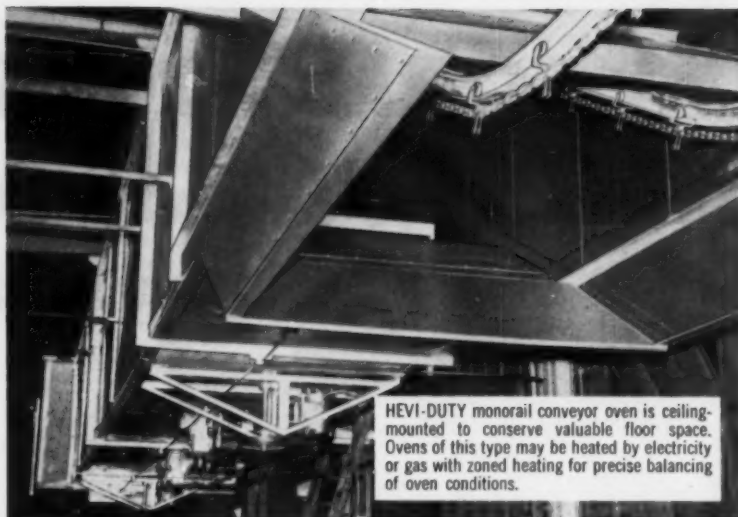
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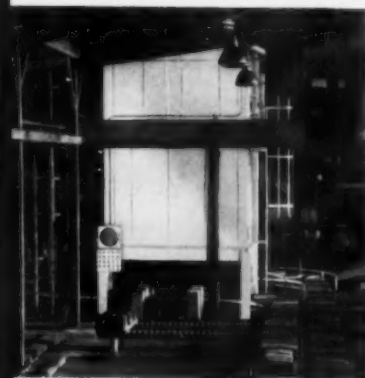
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Molybdenum Sheet . . .

encountered with an unfortunate habit of splitting at 45° to its rolling direction at any scratch or notch. The only known remedy is to avoid all such stress concentrations.

Since the properties at service temperatures depend upon the recrystallization temperature of the sheet, the latter should be held to narrower limits. At present, this varies within the range of 2200 to 2450° F., depending on processing variables in the sheet mill.

Forming—Much of the paper under review describes the author's experiences in the forming and joining of the 0.5 Ti alloy sheet, and the original document should be consulted for details. Shearing or sawing is done after preheating to 700° F. ("Tempilstick" control). Forming by a variety of processes, such as spinning, stamping, "floturning", stretch forming, is done on hot sheet; proper working temperatures vary with thickness, ranging from 600° F. for 0.020-in. sheet to 2200° F. for 0.320-in. The authors apparently favor hot headed mechanical fasteners; rivets are heated to 1100° F. and the parts being joined are heated above their transition temperature to avoid cracking. While welding, either by resistance (spot) or fusion, is possible it requires very precise equipment and unusually close control.

Coatings—Many protective coatings have been tested in the Marquardt laboratories, and the authors believe that "Chromalloy W-2" is the best. The completed molybdenum part is packed in a proprietary powder in a sealed retort and heated to 2000° F. several hours, during which a case about 0.002 in. thick forms on all surfaces by processes similar to cementation. The

BEHAVIOR OF METALS AT LOW TEMPERATURES

Contains three lectures important because of educational value. "Behavior of Single Crystals and Pure Metals", "Influence of Mechanical Variables", and "Influence of Metallurgical Factors". 90 pages—6x9—red cloth—\$3.00. Clip and send to ASM Technical and Engineering Book Information Service, Metals Park, Nov. 1964, Ohio.

final surface is as smooth as the original; "throwing power" is excellent (even under rivet heads), reproducibility is good and the coating resists thermal shock. Samples under tension were heated to 3000° F. for 90 min. before oxide vapors became visible.

E.E.T.

Continuous Casting

Digest of "The Rational Design of a Mould for the Continuous Casting of Steel", by G. I. Kozlitsin and L. N. Kolybalov, *Stal*, Vol. 3, 1957, p. 209-213.

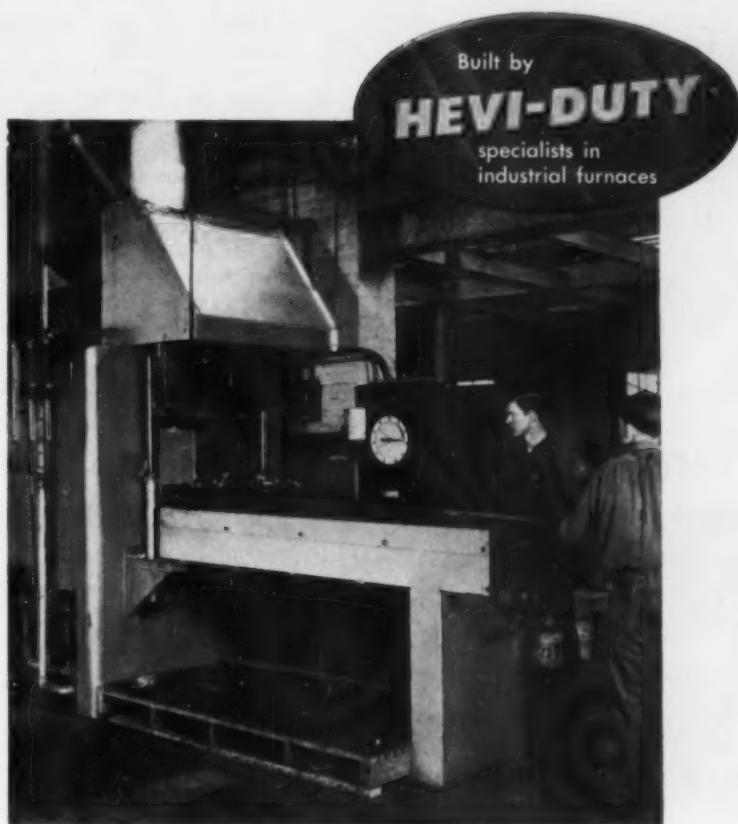
THE PAPER DISCUSSES in detail the construction and operation of three types of machines for the semi-continuous casting of stainless steels. In particular, it discusses a reciprocating mold-type machine which is cheaper to operate than the standard stationary and spring-loaded types. This article is indicative of the very wide interest taken in Russia in continuous casting of steels.

One of their most important advances has been the successful continuous casting of large tonnages of rimming steels after vacuum degassing at about 30 mm. pressure.

The first installation described is the stationary mold machine at the Red October works. The ingot or billet is removed by a crosshead running on two vertical screws driven by a 9-kw. electric motor. The speed of withdrawal may be varied from 0 to 6 in. per min., and billets of 0.6×2.5 -in. cross section and about 7 ft. long are produced. The duration of casting a billet of the above size at a speed of 4 in. per min. is about 20 min. Babcock & Wilcox Co. have experimented with a similar unit.

In this process, however, where the solidifying billet moves in relation to the mold surface and at a speed of removal of 4 in. per min., the solidified rim of metal near the top of the billet only has a thickness of about 0.2 in. If the frictional force between the solidified rim of the billet and mold is increased due to poor lubrication, this crust is easily broken and defects occur in the billet surface. When a major break occurs, it can be repaired only after stopping the machine.

Since 1951, a series of improvements have been carried out on this



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Continuous Casting . . .

type of casting machine. The mold has been set on four spiral springs which contract in relation to the frictional forces between the mold and billet surface. In this instance, the springs are so selected that an increase in the frictional force will not result in fissuring of the billet, but will cause a downward movement of the mold at about the same

speed as the billet, thus releasing the tensional forces on the billet. This type of machine is in operation on two experimental machines in the United Kingdom.

The greatest improvement was found in a machine designed so that there was no relative movement between the mold and billet during casting. At the end of the downward movement of the mold (a displacement of 2 in.), the mold returned to its original position three

times as fast. However enough time is allowed during the 2-in. movement to allow a thick layer of solid steel to form, and thus any defects which may form are limited to small laps and occur when the mold returns quickly to its original position. This reciprocating motion is controlled by a cam mechanism and requires no more power than the original stationary mold. The advantages claimed are that the reciprocal motion of the mold is effective in preventing defects in the billet and lends itself to fully automatically controlled continuous casting.

W. A. MORGAN

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Present Status of Nuclear Power

Digest of "Current Nuclear Power Developments and Their Outlook", by Karl P. Cohen. Paper presented to Energy Resources Conference, Denver, Colo., Oct. 16, 1958.

THE ROSEY HOPES that many atomic-electric power stations would be promptly built — so widely held by industrialists throughout the world a few years ago — have been replaced by the sober realization that such plants are quite expensive and much is yet to be learned about their economical design and operation. Nevertheless, enough is now known so that firm prices and appropriate performance guarantees can be had from responsible manufacturers for 200,000-kw. central stations to operate in 1963 as outlined in the table below:

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per kw.	\$135 to 185	\$300 to 350
Operating costs, mills per kw-hr.		
(70% load factor)		
Capital		
charges	3.1 to 4.2	6.8 to 8.0
Operation	0.6	0.7
Fuel	2.0 to 3.5	3.0 to 4.0
Total	4.7 to 8.3	10.5 to 12.7

It is rather remarkable that the top of the range for conventional fuel plants (8.3 mills per kw-hr.) is so close to the low figure (10.5) for nuclear power plants. It indicates that this gap can be bridged by manufacturing economies when an increased number of plants can be built; by decreased engineering



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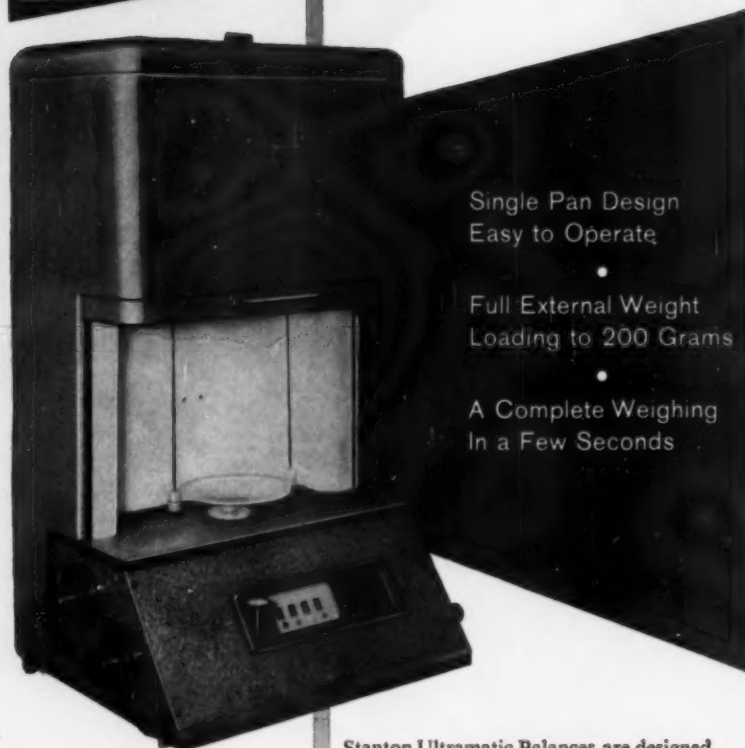
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Nuclear Power . . .

charges as more information is gained; by discovering the best combination of fissionable material, coolant, and auxiliary equipment—superheaters, for example; and by less extravagant design as we know more about the capabilities of the equipment and its parts. (For example, General Electric's Vallecitos boiling water reactor was designed for maximum thermal output of 20,000 kw.; it is operating at 30,000 and undoubtedly can produce safely and continuously 40,000 kw. of heat or more.)

"The prospects are therefore excellent that nuclear power stations using fissionable fuel will be operating as sound commercial propositions in the United States—in high cost fuel areas by 1965, and quite generally in 1970." Edward Teller, the principal American spokesman, suggests A.D. 2000 as a reasonable date for achieving commercial power from the fusion reaction.

In general terms, the existing British program is based on gas-cooled, natural uranium, graphite-moderated. This removes dependence on enormously expensive plants for isotope separation and enriched fuel, but involves many operating difficulties since natural uranium is so unstable under high heat and radiation. Consequently, the new plants in the British program are to use enriched uranium, thus approaching the American stream of development centered on water cooled, water-moderated, enriched uranium.

Such pressurized power systems are even now approaching the status of standard propulsion for U.S. Naval vessels, and the economic gap between floating power plants of the two varieties (fossil fuel versus atomic) is no greater than that quoted at the outset for stationary ones.

"The Soviet reactor development program disclosed in 1955 resembled our own in many ways. They have about 2,000,000 kw. of water cooled nuclear power plants under construction, roughly half graphite-moderated, and half water-moderated. They are using enriched uranium as fuel and are trending away from metal towards oxide fuels. They are planning reactor experi-



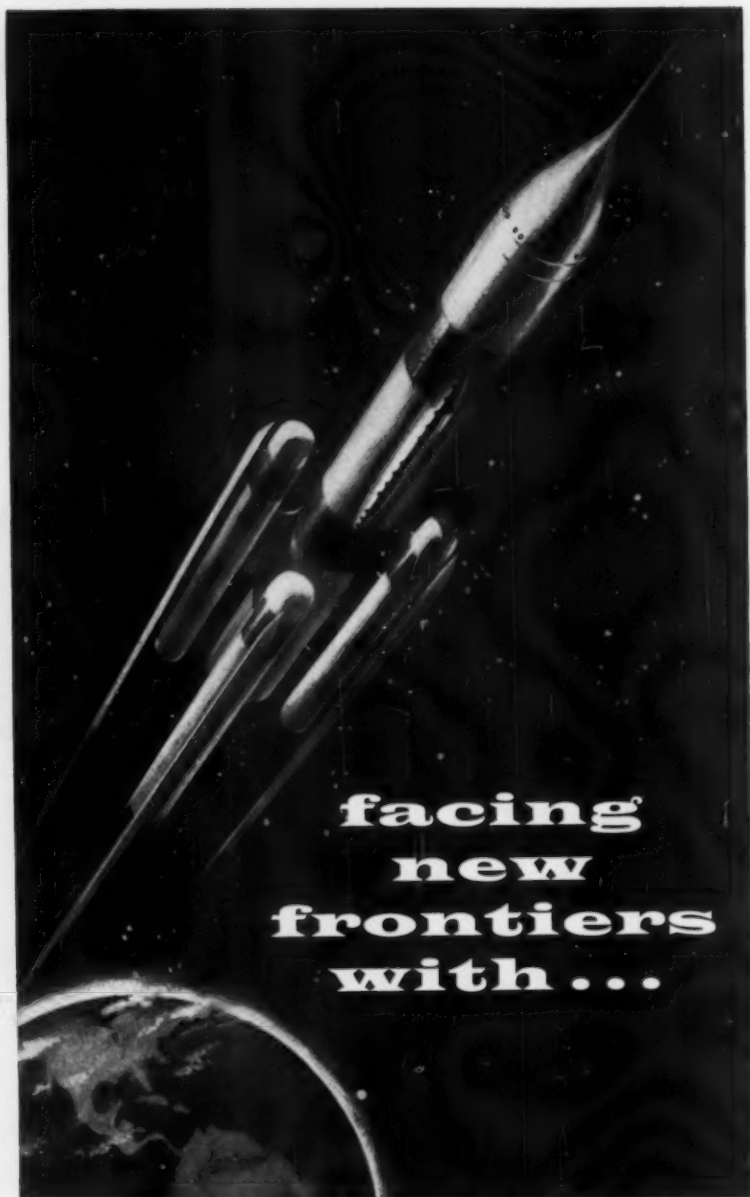
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Nuclear Power . . .

ments with sodium cooled, homogeneous and other reactor types on quite an impressive scale; their idea of a reactor 'experiment' appears to be one generating about 50,000 kw. The Russians at Geneva exhibited models of reactors which were not described in their speeches, and vice versa. One might conclude from this haziness about the details that they are revising their program."

While a promising civilian application is process heat, fresh water from salt by distillation rather than by ion exchange or other separation processes is not a reasonable idea. To make the desert bloom as a rose would require water costing no more than 5 to 10¢ per 1000 gal. Cities could pay ten times as much for domestic use. This may well be within the range of possibilities of nuclear energy.

E.E.T.

Evaluation of Stresses at High Temperature

Digest of "A Machine for the Evaluation of High-Temperature Alloys Under Combined Static and Dynamic Stresses", by P. E. Hawks and C. H. Ek. Paper presented at the Annual Meeting of the American Society for Testing Materials, Boston, June 1958.

MANY MATERIALS are subject to combined static and dynamic stresses at high temperatures (for example, gas turbine buckets). General Motors Corp. has built a number of machines to evaluate alloys for operation under these conditions. The machines can apply static stresses up to 85,000 psi. simultaneously, with cyclic flexural stresses to 45,000 psi. using 1/4-in. diameter specimens. Frequency of flexural stress application, 450 to 650 cycles per sec., is of the same order of magnitude as that encountered in service.

Static loading is applied through a dead-weight lever arm system. Dynamic flexural stresses are applied through an electromagnet and regenerative feedback system which gives resonant vibration in an elastic system composed of the specimen and the axial loading assembly. The specimen is heated by an atmospheric air-acetylene torch with tem-

thermal thicket

Problem: The heat barrier which now hinders hypersonic aircraft and missiles.

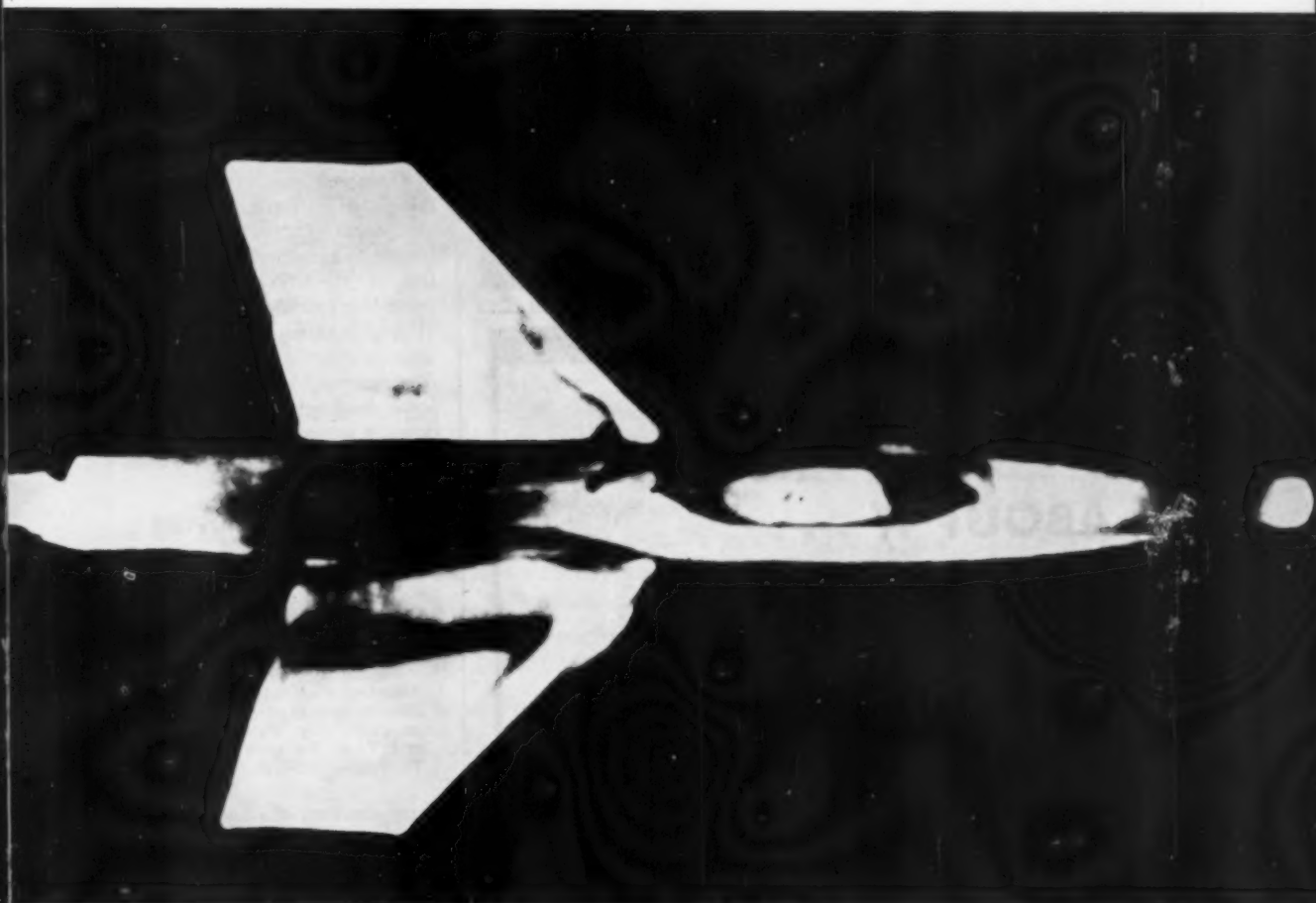
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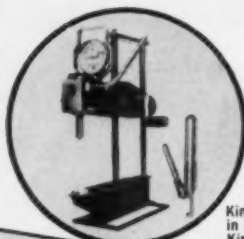
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Tests were performed on Allegheny-Ludlum alloy A 286 at 1100° F. and General Motors alloy GMR 235 D at 1800° F. A constant static stress level (a percentage of the 100-hr. stress-rupture value) was maintained with varying fatigue stress levels giving failure times to 100 hr.

These tests indicate relatively little loss in allowable dynamic stress component as the static stress component is increased to a high fraction of the 100-hr. stress-rupture value. At low static stresses, that is, at approximately conventional fatigue testing conditions, the S-N diagrams are nearly horizontal at lower temperatures with slope increasing as temperature is increased.

C. O. SMITH

Effect of Alloying Elements on Hydrogen in Steel

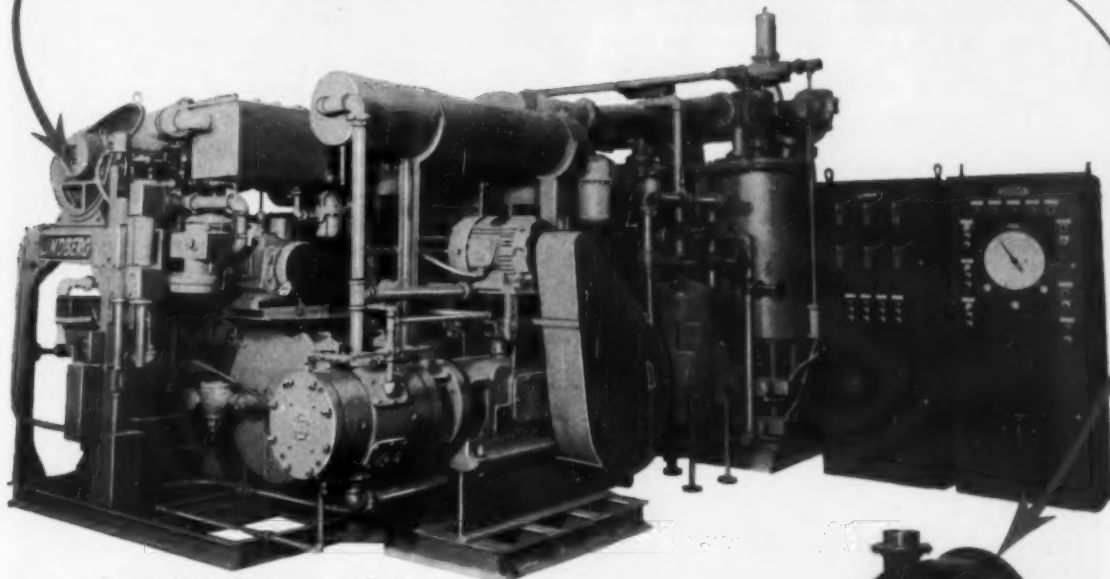
Digest of "The Influence of Alloying Elements on Hydrogen Content and Hydrogen Diffusion in Steel", by Yu A. Klyachko and T. A. Izmanova, *Stal*, Vol. 17, No. 6, 1957, p. 507.

THE ADDITION of alloying elements to iron and steel affects the diffusion of hydrogen and solubility in the solid alloy. The complete removal or "fixing" of hydrogen in large forgings or castings, and its diffusion during pickling processes, is important in preventing cracking or embrittlement. The authors have therefore studied the solubility and rate of diffusion of hydrogen in binary and ternary alloys of iron.

The experimental alloys were

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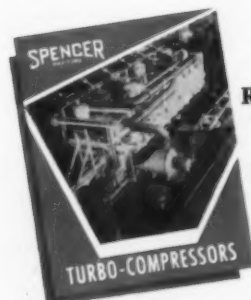
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Hydrogen in Steel . . .

melted in a high-frequency induction furnace under a basic slag. The base material was Armco iron, and calcium was used as the deoxidizer. Alloys of the following types and composition ranges were produced:

1. Fe-C (0.025 to 2.64 C)
2. Fe-Si-C (0.97 to 4.32 Si, 0.035 to 0.50 C, 0.12 to 0.14 Mn)
3. Fe-Mn-C (0.76 to 14.4 Mn, 0.035 to 0.96 C, 0.10 Si)

4. Fe-Zr-C (0.13 to 1.48 Zr, 0.03 to 0.45 C)

5. Fe-Ti-C (0.10 to 3.90 Ti, 0.03 to 1.15 C, 0.1 Si, 0.1 Mn)

The alloys were tested in the forged and cast and quenched condition. Two ingot molds were used. A bottom-pour type produced an ingot which could be tested immediately for hydrogen content by vacuum fusion. An ingot formed in a "big-end-up" type was put into a special container so that it could be immersed in mercury for a month

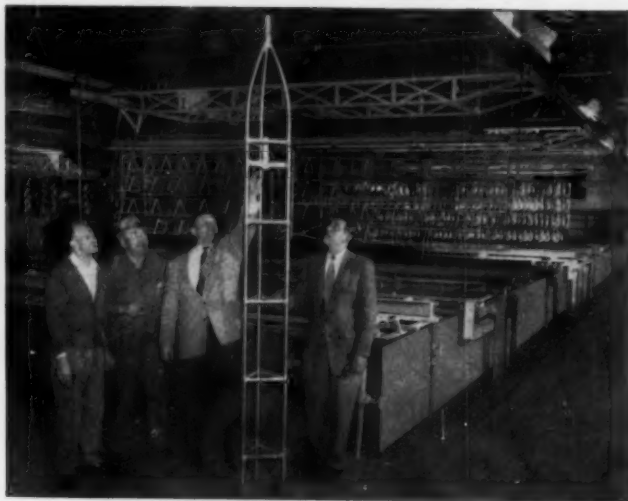
or more. This latter ingot was then forged to 15/32-in. diameter rods, machined to 3/8 in. and then cut into 3/8-in. long specimens. Hydrogen was determined by vacuum fusion.

In the experiments in which the ingots were kept under mercury at room temperature, the quantity of hydrogen liberated was measured each day. The results for all of the systems show that the rate of hydrogen liberation is at first rapid but after about five days levels off. Results are given for the Fe-Ti-C alloys which show that with increase in the titanium content the amount of hydrogen absorbed during melting is increased. For the same carbon content, an increase in titanium also decreases the rate of liberation of hydrogen. However, in comparing a high-titanium low-carbon alloy (3.90% Ti, 0.035% C) with a low-titanium high-carbon alloy (0.10% Ti, 1.15% C), the high-carbon alloy has a much slower rate of gas evolution, that is, the carbon content seems to be more effective in slowing up hydrogen elimination than the titanium content. For the other compositions, it was shown that as the content of the alloying elements increases, the mobility of hydrogen at room temperature decreases. Listed in order of decreasing effect, these elements are zirconium, titanium, carbon, manganese and silicon.

The hydrogen remaining after prolonged holding was determined by "big-end-up" test ingots at 1560° F. These tests confirmed that vacuum heating released only slightly more hydrogen than diffuses out at room temperature. Hydrogen in the as-forged and in the as-cast specimens was determined by vacuum fusion. The as-forged metal contained considerably less hydrogen than the as-cast alloy although the variation of hydrogen content with composition was similar.

The results of this work show that alloying elements increase the solubility of hydrogen in steel and in no instance decreases it. Some of the elements do this by the formation of stable hydrides. They may also promote the formation of austenite or martensite. Titanium and zirconium, and surprisingly carbon, can be classed as hydride-forming elements. All the elements studied lowered the mobility of hydrogen in iron alloys.

W. A. MORGAN



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Effects of Mechanical Working on Inclusion Deformation

Digest of "Some Effects of Mechanical Working on the Deformation of Non-Metallic Inclusions", by F. B. Pickering, *Journal, Iron and Steel Institute*, Vol. 189, June 1958, p. 148-159.

THE TYPE AND DISPERSION of non-metallic inclusions are known to have important effects on the mechanical properties of steels, in particular, fatigue properties, transverse ductility, and impact behaviour. Many studies have been made of the inclusions present in steel ingots. However, this paper describes one of the first attempts to determine what happens to these inclusions during subsequent hot working.

Experimental iron-oxygen-silicon alloys containing inclusions of iron oxide, inclusions of the important silicate group, and duplex oxide-silicate types were examined. The effects of a range of rolling reductions and temperatures on the inclusions were investigated by metallographic

methods. The results can be explained if it is assumed that the deformation of the inclusions is due to the forces at the inclusion-metal interface. These will increase with decreasing rolling temperature and increasing rolling reduction. On the other hand, the inclusion will become less plastic with decreasing rolling temperature. It will then be more likely to fracture.

At high rolling temperatures and small reductions, massive silicates are deformed into ellipsoidal masses. In duplex inclusions, the more plastic phase may be squeezed to the ends of the less plastic phase. At lower temperatures, fracture occurs at various stages of deformation; this disperses the inclusion. Dispersion of duplex inclusions may be assisted by fracture along the interface between the two phases. At still lower temperatures, the inclusions are even less deformable and the fracturing forces are greater. They may then be broken up into stringers elongated in the direction of rolling.

The stage of reduction at which fragmentation occurs has an important influence. If it occurs early, the
(Continued on p. 198)

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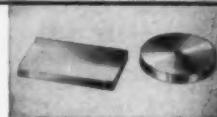
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3 Large capacity vertical furnace for heat treating large parts.

The three furnaces shown on this page are units of the facilities of commercial heat treating plants in three different sections of the country.

Today, with the ever growing demand for *better* heat treating, economical volume equipment of this sort is becoming essential and the commercial heat treater has been alert to industry's requirements.

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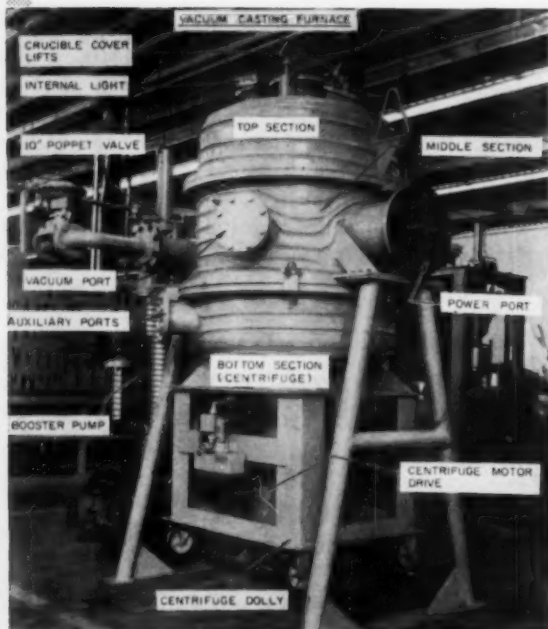
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Radioactive materials handling investigations are safely carried out with this Stokes prototype vacuum furnace. It is remotely operated by manipulators and other external controls. This installation represents another specific requirement met through Stokes flexibility.



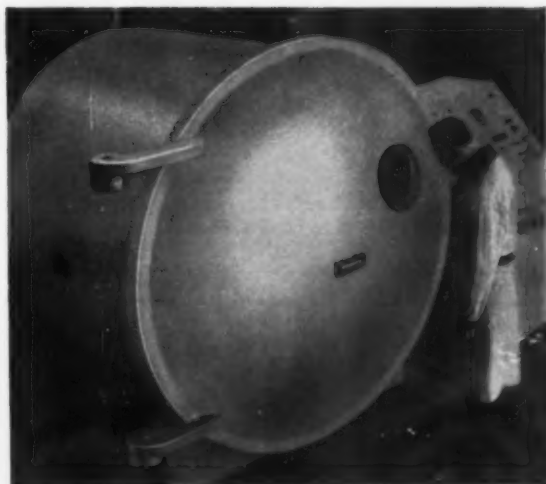
Uranium melting on a production basis is accomplished by this Stokes induction melting furnace. Designed for safety and convenience, the furnace is serviced from the top and features a removable bottom section to facilitate handling of poured materials. It is typical of Stokes inherent flexibility.

Progress in Vacuum Metallurgy

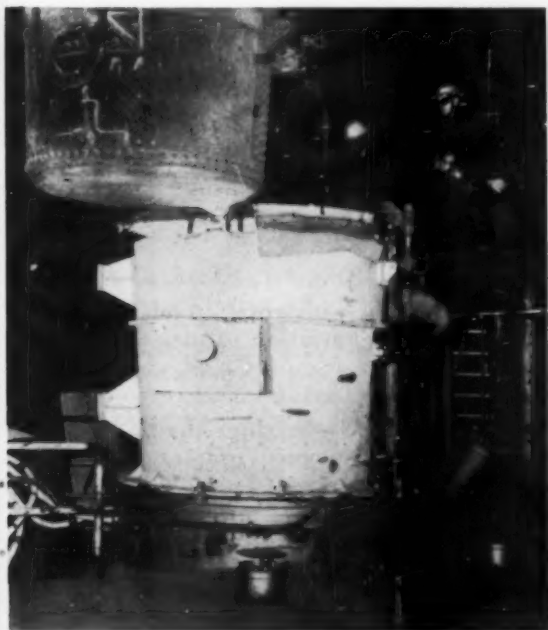
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vacuum equipment ranges from small compact R&D models to full production units. Stokes is geared to meet specific customer requirements for many types of special metallurgical equipment. All Stokes systems are offered complete, making Stokes a single source of responsibility for performance and reliability, both before and after the sale.

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First acid open hearth, vacuum stream ladle degassed
—Air pouring of multiple ingots in the United States took place at Ohio Steel Foundry in May. Stokes provided the equipment. The results showed low hydrogen values, good inclusion reduction and excellent physical property improvement.

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Inclusions . . .

dispersed fragments are deformed and a second fracturing process may even occur. If it occurs late, the fragments may develop a characteristic fish-tail form at their ends. This is attributed to the large forces at the metal-inclusion interface causing preferential deformation of the outer layers. If it occurs very late, clean fractures may still be present. In extreme instances, the matrix may not fill in completely between the fragments, leaving unwelded voids. Extensive craze cracking may also be present in the larger inclusions.

It appears essential, if large injurious silicates are to be converted into less harmless dispersion, to promote early fracture into many fragments. Initial working at low temperatures would encourage this. Working at high temperatures may then be desirable to improve the form of the fragments. Multiple cold working with intermediate reheating would be better than all working in one stage. L. E. SAMUELS

Hot Cracking in Welds

Digest of "The Mechanism and Origin of Solidification Cracking in Welds", by I. I. Frumin, *Avtomaticheskaya Svarka*, No. 1, 1957, p. 88-102.

IN WELDING, one of the most feared defects is hot cracking. The direction of hot cracking generally is in the direction of growth of the columnar crystals. A root opening is a region of poor thermal conductivity and therefore is the origin of hot cracks in many instances. The tendency toward cracking increases with decrease in shape coefficient, which is the ratio of width of bead to depth of penetration. Pear-shaped welds are particularly prone to cracking. This paper is a dilatometric study of hot cracking in the submerged-arc welding of mild and alloy steels. The weld metal undergoes expansion and contraction immediately after it solidifies.

The deformations measured at a tangent to the edge of the weld puddle are significant for cracking. These deformations were measured

by a sensitive extensometer so located that its two points were located on the same drag line or solidification ripple. A bare Pt-PtRh thermocouple (0.001-in. wires) was embedded in the weld between the points. The extensometer points were 0.08-in. tungsten rods sharpened to a 60° cone. Welding proceeded for 1 min. before the extensometer points were immersed back of the arc, and continued for 1 min. thereafter. Oscillograms of the thermocouple output were taken as well as motion pictures (one frame per second) through the eyepiece of the measuring microscope. The two extensometer points were ¼ in. apart, and freezing, of course, started simultaneously at the two points. Preliminary tests in which the extensometer points were immersed in the slag but not in the weld metal indicated a very slight contraction during freezing.

The first tests were made in mild steel at room temperature, using a high-manganese flux, 720 amp., 36 v., 10 in. per min. travel speed. The steel was 1½ in. thick, 8 in. wide.

(Continued on p. 202)

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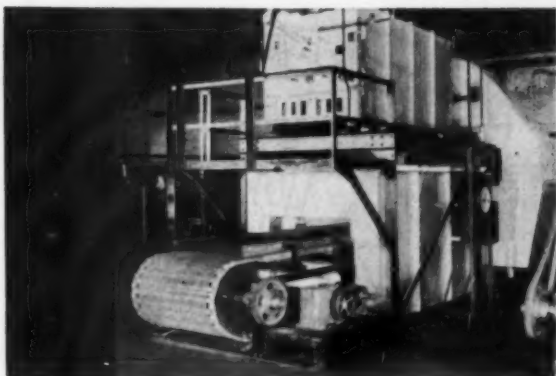
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Hot Cracking . . .

During the first 8 sec., the extensometer recorded no change. From 7 to 10 sec. an elongation of 0.15% was recorded. During this period the temperature was 1510 to 1480° C. (2750 to 2695° F.) and the cooling rate was 37.5° C. (99.5° F.) per sec. From 10 to 15 sec., there was sudden contraction to -0.45%, beyond which little further contraction occurred. The same type of result was secured with higher carbon and Cr-V steels.

To determine the temperature at the initiation of a hot crack, bars of steel (0.22 C, 0.31 Mn, 0.034 S) 4% in. square, 24 in. long, were cut in two so that a gap of 0.06 in. wide extended across the path of the arc. The extensometer points straddled the crack caused by the gap. Instead of elongation reaching a maximum and being followed by contraction, elongation continued throughout the cooling, reaching 4½% in 60 sec. In five tests the temperature at which the crack occurred varied from 1300 to 1390° C. (2370 to 2535° F.). With the Cr-V steel there was 0.25% elongation at 11 sec. Contraction then occurred until 16 sec., at which time the temperature was 1130° C. (2065° F.) and a crack started. Elongation resumed at once and continued during further cooling.

Preheating the Cr-V steel to 380° C. (715° F.) not only prevented cracking but eliminated the expansion period. The cooling rate during freezing was 10° C. (50° F.) per sec. and no change in length occurred until 14 sec., by which time the weld had cooled to 1150° C. (2100° F.). Slow contraction then set in, amounting to -0.4% at 50 sec. Similar results were obtained with the low-carbon steel preheated to 400° C. (750° F.). Preheat alters the character of the deformation during and just after freezing.

The results show that hot cracking occurs during the liquid-solid transition in the bead containing grain-boundary liquid under deformation arising from nonuniform heating. Without preheat and when cracking does not occur, elongation precedes contraction. Not over 0.5% elongation was observed in any test, and this can be accommodated by any metal free from hot shortness.

D. L. CHURCHILL



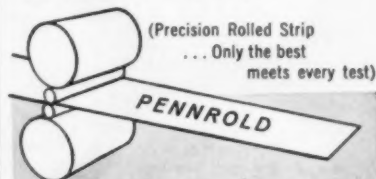
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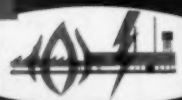
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Shot-Peening

Digest of "Shot-Peening in Relation to Gear Tooth Scoring", by John C. Straub. Paper presented at the annual meeting of the American Society of Lubrication Engineers, Cleveland, April 24, 1958.

GEAR TOOTH failures are of three types: tooth breakage, pitting, and scoring. Tooth breakage, due to fatigue, is of course catastrophic. Pitting, while it is a less disastrous condition caused by high contact stresses, is also believed due to fatigue. Scoring, like pitting, is a surface condition, but it is not related to fatigue. It may occur early in the gear's use, and is caused by a

welding of tooth surfaces, rather like the seizure of a journal and bearing.

Gear design does not always permit a simultaneous solution to all three types of failure. For example, to reduce a tendency to scoring, a lower sliding velocity at the tooth surface is desirable. This may be achieved by reducing the pitch of the gear, but this leads to a greater stress on the teeth and so encourages failure by fatigue. So, an increase in the endurance limit permits greater flexibility of design, and gear tooth scoring is minimized. Actually, peening has no direct relationship to the scoring problem.

Shot-peening has been used to increase the endurance limit of springs for a number of years. Its effective-

ness is greatest in long-life, low-stress applications. For instance, the endurance limit of an automotive gear with a life of ten million cycles can be increased 50% by peening. For an expected life of only 100,000 cycles (with correspondingly higher stresses), peening may increase the endurance limit by only 10%.

Peening is effective on both hardened and machinable gear teeth, and the slight increase in roughness caused by peening does not seem to affect gear performance.

Visual examination does not provide an accurate appraisal of the quality of a peening job. Consequently, the efficacy of peening is judged by the curvature produced on a standard test strip that has been peened on one side only, while passing through the same cycle as the work to be assessed. The curvature of the sample offers a semiquantitative indication of peening efficiency, so long as it is combined with some measure of the coverage of the operation. Coverage is defined as the proportion of area that has been impacted during peening.

While a coverage of 98% is said to be "full", experiments show that gears peened for a period several times as long as that required for full coverage display a greater improvement in their endurance limit. Clearly, an economic balance between greatest increase in endurance limit and production efficiency has to be sought.

It is important that the shot used in peening is uniform and contains a minimum of broken pieces. The most economical operation is usually obtained by using small uniform shot with a high velocity of impingement. The shot themselves are chosen for their resistance to breakage rather than for a high hardness value.

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Many people think of tubing only in its most common form—round. As design engineers and buyers, you know it can be produced economically in a large variety of unusual shapes. But have you ever seen the particular shapes illustrated on this page? They are samples from production runs formed to extremely close tolerances to satisfy specific design requirements. End uses include Bourdon springs, surgical instruments, batons, aircraft structural parts, gun drill shanks, radar screens, door latches, electrical equipment, antennas, golf club shafts, fishing rods and bushings. However, we don't know where all the different shapes are used, or why they are required. But our ability to form them saves manufacturers

in many industries considerable time and money in the fabrication of their products.

Superior regularly produces shaped tubing in many analyses of stainless steel, carbon and alloy steels, nickel and nickel alloys, and glass sealing alloys. Also in titanium and beryllium copper. Shaped tubing is generally supplied in the as-formed temper (annealed before shaping), but many special tempers can be supplied.

We can probably supply your requirements at low cost, in good time. Data Memorandum No. 17 gives full details about Superior Shaped Tubing. Write for a copy today. Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to $\frac{3}{8}$ in. OD—certain analyses in light walls up to $2\frac{1}{2}$ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

... HEAT-TREATING - 1960 ...

CAMBRIDGE METAL-MESH BELTS are the answer to the big problems you'll face in the competitive '60's—tighter operating costs, higher production and consistent quality.

Continuous movement of products through heat-treating operations, as well as quenching, washing and drying, speeds up production and cuts costly manual handling.

Heat, liquids or gases flow through the belt and around the product for fast, thorough processing... assuring uniformly high quality.

Superior belt design and manufacturing techniques mean longer belt life, fewer repairs, lower operating costs.

Belts can be made heatproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

Call your Cambridge Field Engineer now. He'll be glad to discuss any aspect of Cambridge Belts—from manufacture to installation and service. Look in the yellow pages under "Belting, Mechanical". Or, write for **FREE 130-PAGE REFERENCE MANUAL**.



The Cambridge Wire Cloth Co.

Department B • Cambridge 9, Md.

Manufacturers of Wire Cloth,
Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

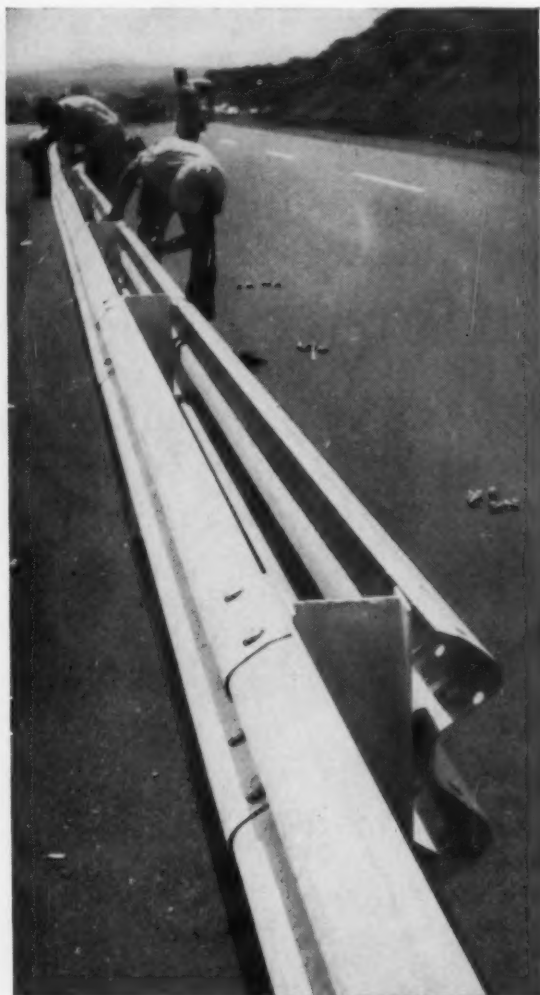
Hot-Dip Galvanizing Replaces Painting

...and Proves A Life Preserver For Highway Life Guards

It is estimated that road building to the extent of six billion dollars will make 1959 the biggest highway construction year since Congress, in 1956, authorized the 41,000 mile interstate highway system.

Last year, as a part of this continuing program, 11 miles of hot-dipped galvanized guard rail were installed on the Pennsylvania Turnpike near Somerset, Pa. The rail was galvanized after fabrication and delivered to the site as needed. Under normal conditions, construction crews installed an average of 3000 feet per day. For complete protection against atmospheric corrosion, galvanized bolts were used to fasten the rails in place. This type of double faced guard rail has become increasingly popular especially on older highways where narrow medial strips are a hazard.

Noteworthy is the proven fact that the ultimate cost of hot-dip galvanizing is lower than painting because it eliminates the recurrent expense of *re-painting*.



Here is an example

The hot-dip galvanized bridge railing shown here was installed on the Merritt Parkway near Milford, Conn. in 1938. In the ensuing 20 years it has retained its appearance and strength without painting. This is just one of the many installations where galvanized steel is saving the nation's Highway Departments millions of maintenance dollars every year. Thanks to the protective zinc coating, galvanized highway structurals are immune to atmospheric corrosion and have the added advantages which the inherent strength of steel provides.

ASTM SPECIFICATIONS

Steel products to be galvanized after fabrication, and approved for installation on inter-state highways, are covered by ASTM Spec. A123 and apply to:

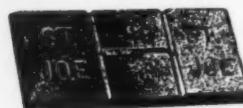
- Bridge Structurals
- Decking and Railing
- Grating
- Fence Posts
- Sign and Reflector Supports
- Expansion Plates
- Rocker Plates
- Guard Rails
- Lighting Standards

NOTE: ASTM Spec. A123 corresponds in most cases to a similar specification of the American Assoc. of State Highway Officials, e.g., ASTM A123 is the same as AASHTO Spec. M111-55.

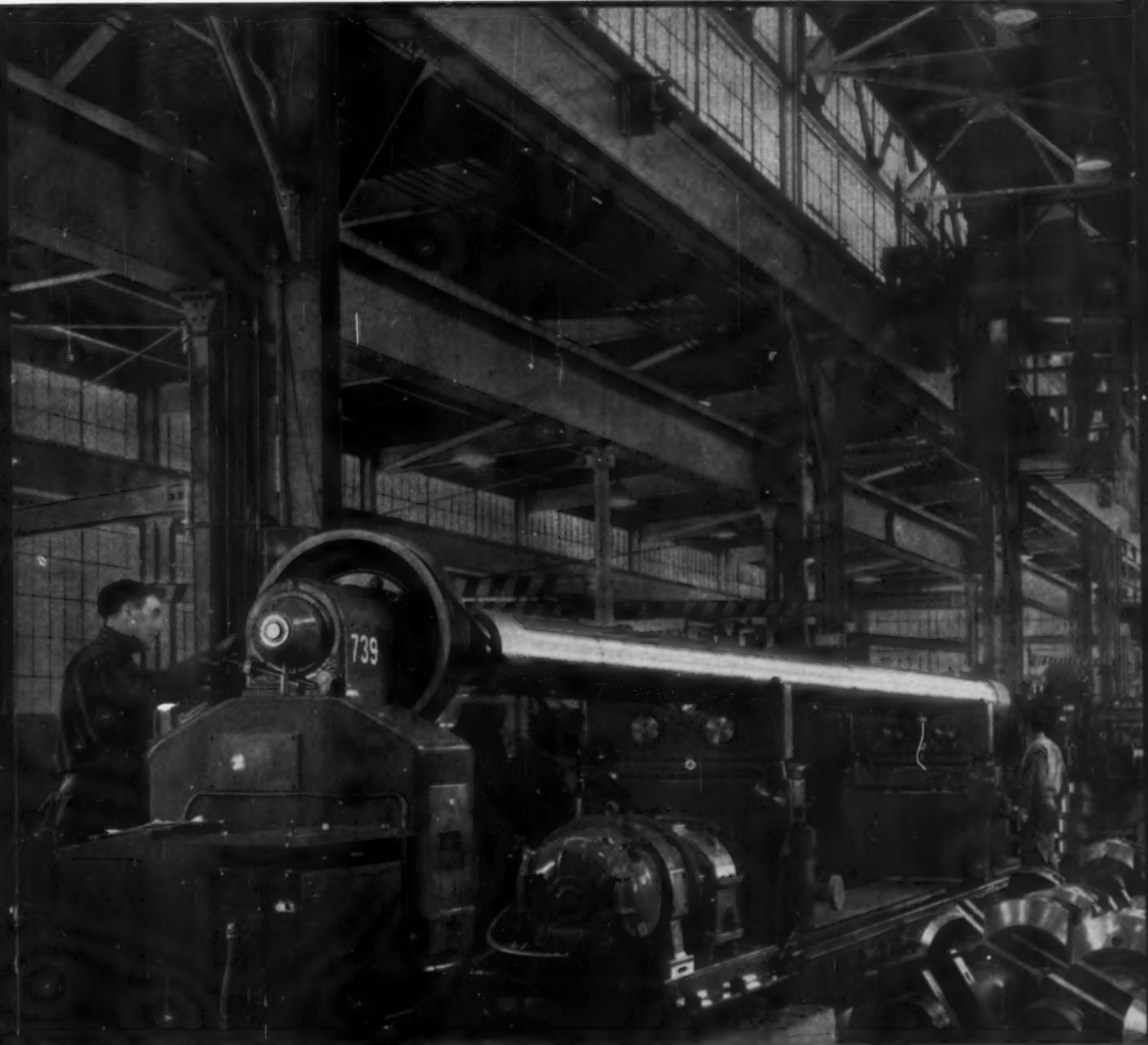
ST. JOSEPH LEAD COMPANY

ST. JOE

250 Park Avenue
New York 17, N. Y.



EN-197



WHO FORGES THE TOUGH ONES? and dynamic balances them, too?

To further National Forge's reputation for producing precise forgings, we've installed one of the largest, most accurate dynamic balancing machines in use. Our American-Trebel has a 33,000-pound, 60-foot capacity.

Pictured on the machine is a 42 ft. propeller shaft that has been forged, machined, and hollow bored—all operations done in our National Forge plant. NF specialists

are shown balancing this gigantic 15,500 lb. shaft.

If you want one responsible source to produce and control the quality of your forgings...from melting and forging the steel through machining and dynamic balancing... call National Forge. Let us quote on your next job—and *prove* "who forges and dynamic balances the tough ones . . . best!"



NATIONAL FORGE COMPANY
IRVINE, WARREN COUNTY, PA.



SPECTROSCOPISTS!

Take advantage of a complete line of



NATIONAL ELECTRODES and POWDERS

Whatever technique you use...whether you are doing quantity runs or special individual tests...there is a "National" spectroscopic product to assure accurate results every time.

NEW GRAPHITE GRADE SPK—offers superior *reproducibility*. A free sample of this high-purity rod will prove this on your tests. Also available in preforms.

GRAPHITE GRADE AGKSP—the accepted industry standard in high-purity electrodes. Available in rods and preforms.

CARBON GRADE L113SP—a high-purity carbon rod for specialized applications.

GRAPHITE POWDERS SP1 AND SP2—used as a diluent and for pellet forming.

These products are manufactured from raw material to finished product in NATIONAL CARBON plants. Exclusive purification methods provide a uniform product from end to end and shipment to shipment. Use "National" spectroscopic products on all your analyses.

"National" and "Union Carbide" are registered trade-marks of Union Carbide Corporation

NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N. Y.

OFFICES: Atlanta, Chicago, Dallas, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco • CANADA: Union Carbide Canada Limited, Toronto





PHOTO BY KARSH OF OTTAWA

"Materials are important to the designer. . .

thats why Talon, Inc. works with Sharon"—THANE E. HAWKINS, chief engineer,
Shu-Lok Fastener Division, Talon, Inc.

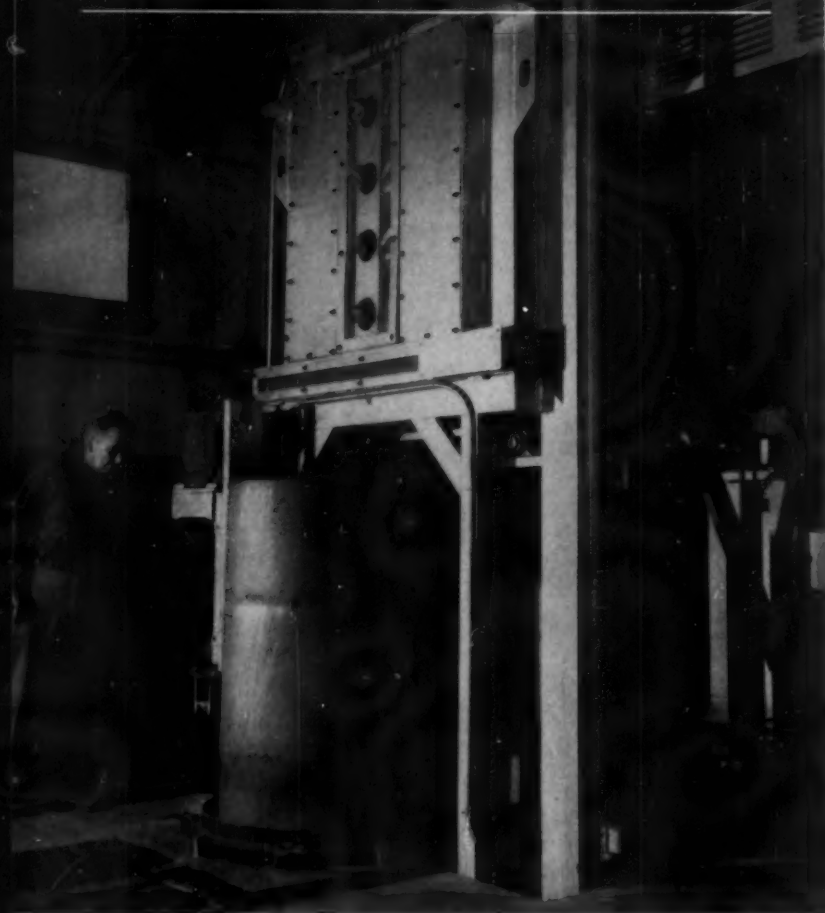
"To design properly the engineer has to know materials—their advantages and limitations," states Thane E. Hawkins, chief engineer, Shu-Lok Fastener Division of Talon, Inc.

"The Shu-Lok, we knew, would have to absorb extra heavy punishment—yet be as inconspicuous as possible. This meant a small, tough precision product. These factors dictated the use of steel—stainless steel. To get the quality stainless we needed, it was only natural to look to *Sharon Steel Corporation, Sharon, Pa.*"



SHARON *Quality* **STEEL**

PRODUCING MISSILE COMPONENTS:



STAINLESS BRAZING PROBLEMS LICKED

By assembling inexpensively-produced components and then brazing them in this Harper Elevator Furnace, Fabriform Metal Products, Inc., Los Angeles, has by-passed high manufacturing costs. Forging, casting and excessive machining have been eliminated in producing a tremendous variety of complicated products . . . including stainless missile and jet engine parts.

Operated on a two-shift basis, the Harper Furnace has not only proved extremely versatile, but has enabled Fabriform to overcome many tough brazing problems. Even metal working dies and molds of tool steel have been copper brazed without decarburization. Recently, a thousand stainless steel bearing housings were copper brazed with only one reject in the lot. Relatively heavy sections of difficult-to-brazing super alloys such as A-286 and Inconel X have been handled successfully. Excellent results have been obtained using a variety of base metals, as well as filler metals including nickel-base alloys.

With the furnace capable of holding a ton of parts stacked 30" high within a 24" diameter, temperatures up to 2100 F can be attained in the inconel retort.

Temperature uniformity is excellent: Placed within loads 20" high, matched thermocouples show no temperature differences.

"The Harper Furnace is extremely flexible and can produce practically any time-temperature cycle within reason," says A. M. Thompson, Gen. Mgr. of Fabriform. "Because we can hold effluent dew points of -90 F, it's possible to do extremely difficult jobs . . . We haven't had a forced shutdown since installation over three years ago."

To reap the maximum benefits of furnace brazing, you'll find it pays to talk to a Harper representative . . . for Harper can build the furnace best suited to your needs: box, pusher, mesh belt, roller hearth, bell, elevator or pit. For detailed information, write: Harper Electric Furnace Corp., 40 River St., Buffalo 2, N. Y.

HARPER ELECTRIC FURNACES

FOR BRAZING, SINTERING, WIRE ANNEALING, BRIGHT ANNEALING, FORGING AND RESEARCH

Protecting downcomers with a heat-resistant concrete lining made with Atlas Lumnite Cement



A heat-resistant concrete lining, being gunited in place, solves the problem of abrasion in this blast-furnace downcomer system. Made with Lumnite calcium-aluminate cement and aggregates, this smooth, jointless concrete lining will withstand the abrasive attack of particles in the gas stream — extending the life of the steel structure.

In new installations or repairs, monolithic linings are easily and economically placed — by guniting, casting or troweling. Unit downtime is reduced because concrete reaches service strength in 24 hours.

Other applications in blast-furnace systems include foundation pads, blast main linings, stove domes and other areas where resistance to heat and corrosion are required.

For convenience, castables bonded with Lumnite cement are available from leading manufacturers of refractories. These are packaged mixtures, ready for use by adding only water. For more information, write Universal Atlas, 100 Park Avenue, New York 17, New York.

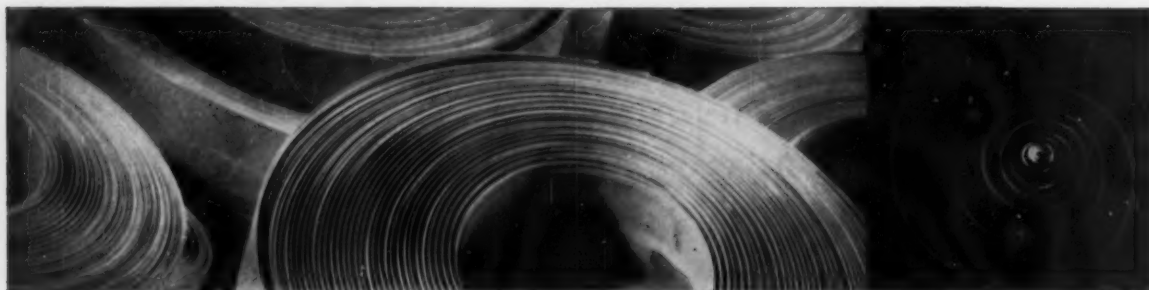
"USS," "Atlas" and "Lumnite" are registered trademarks

L-186



**Universal Atlas Cement
Division of
United States Steel**

OFFICES: Albany • Birmingham • Boston • Chicago • Dayton • Kansas City • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • St. Louis • Waco



Check your requirements against these

Wallace Barnes Cold-rolled Specialty Steels

Furnished in these carbon grades:

1.25 - 1.32% .90 - 1.05% .70 - .80% .59 - .74% .48 - .55%

ANNEALED AND HARD-ROLLED

Thickness

.003 - .010" in widths $\frac{1}{8}$ to $6\frac{1}{4}$ "	.036 - .049" in widths $\frac{3}{8}$ to 13"
.011 - .014" " " $\frac{1}{8}$ to 11"	.050 - .064" " " $\frac{1}{2}$ to 13"
.015 - .019" " " $\frac{1}{8}$ to 13"	.065 - .093" " " $\frac{3}{4}$ to $6\frac{1}{4}$ "
.020 - .035" " " $\frac{1}{4}$ to 13"	.093 - .125" " " $\frac{3}{4}$ to $6\frac{1}{4}$ "

HARDENED AND TEMPERED

Scale-free or scaleless; polished*; polished and blued*; polished and strawed*

Thickness

.003 - .004" in widths $\frac{1}{8}$ to 2"	.031 - .035" in widths $\frac{1}{4}$ to 7"
.005 - .007" " " $\frac{1}{8}$ to 3"	.036 - .040" " " $\frac{3}{8}$ to 7"
.008 - .009" " " $\frac{1}{8}$ to 4"	.041 - .049" " " $\frac{3}{8}$ to 6"
.010 - .014" " " $\frac{1}{8}$ to 5"	.050 - .060" " " $\frac{1}{2}$ to 4"
.015 - .019" " " $\frac{1}{8}$ to 7"	.061 - .064" " " $\frac{1}{2}$ to 3"
.020 - .025" " " $\frac{1}{4}$ to $8\frac{1}{2}$ "	.065 - .093" " " $\frac{3}{4}$ to 3"
.026 - .030" " " $\frac{1}{4}$ to 8"	

*Maximum width for polishing in .010 - .030 thickness ranges is 5 in.

Facilities for processing alloy steels also are available.

Standard sizes normally available for prompt shipments.

Write for a copy of "Physical Property Charts" that give performance characteristics of .90 - 1.05% and .70 - .80% carbon grades.

Wallace Barnes Steel Division

Bristol, Connecticut



**Associated Spring
Corporation**

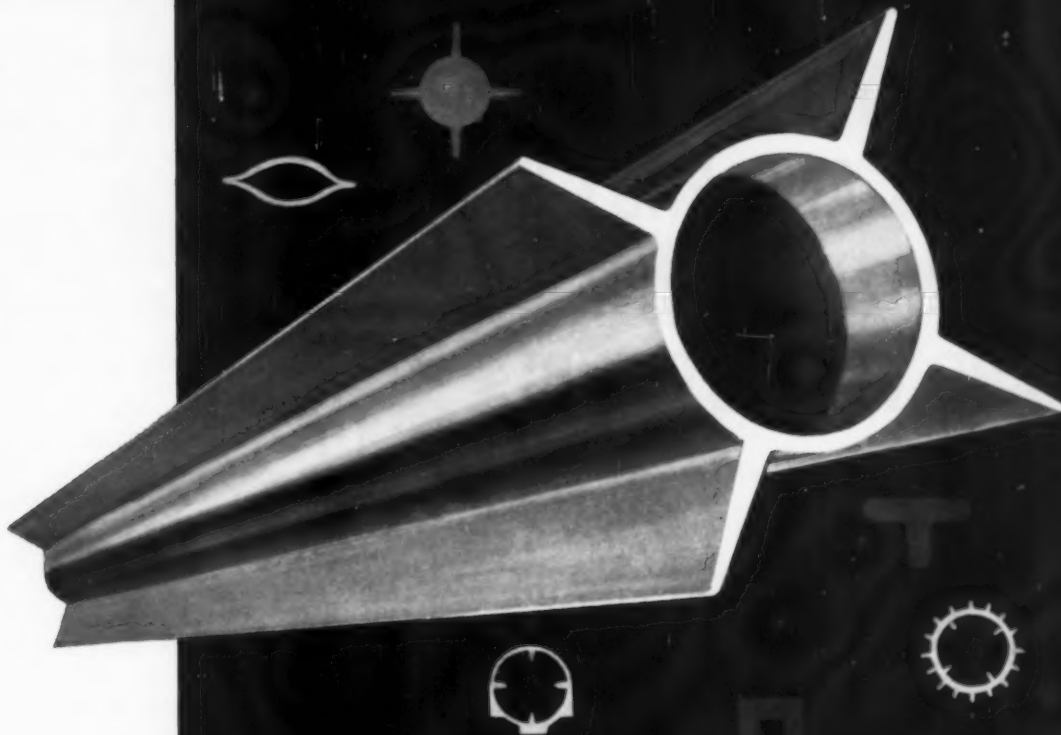
8818

Simple approach to the complex!

CURMET

Custom Extrusions

**offer superior metal properties
—eliminate machining and welding**



Now complex steel shapes, extruded in lengths up to fifty feet, make possible a radically different approach to metal fabrication techniques. The nominal limitations are that the design fit within a twenty-two inch circumscribing circle—have a minimum of five square inches in cross-sectional area.

This flexibility makes it possible to extrude complete units—eliminating many welding and machining operations. The result: *Genuine production savings.*

And the Curtiss-Wright extrusion process, using 24,000,000 pounds pressure, gives the metal non-

directional physical properties—end-to-end uniformity—a fine internal finish. The result: *Substantially improved physical properties in the metal.*

Intricate extrusions can be made from all forgeable metals including ferritic or austenitic alloy steels, titanium and other special purpose materials.

A twenty-four page brochure on CURMET custom extrusions has just been published. It presents the complete story on this exclusive method—tells how it can save time and money—how it achieves superior properties in the metals used. Write for it today.

CURTISS-WRIGHT
CORPORATION

78 GRIDER STREET

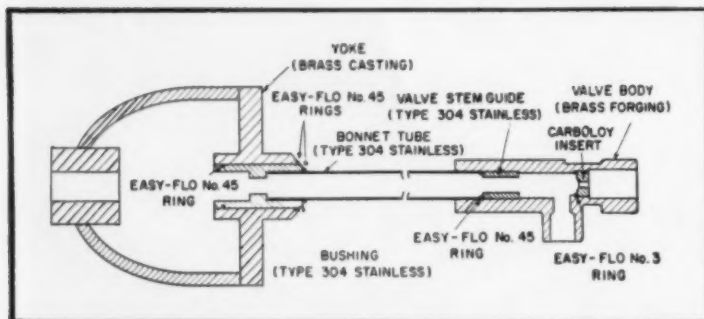


METALS PROCESSING
DIVISION

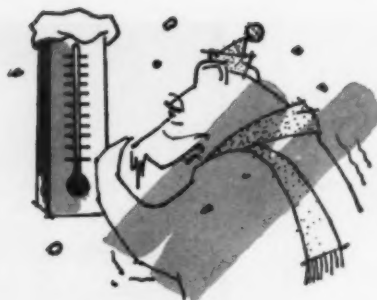
BUFFALO 15, NEW YORK

*Don't Worry About Joint Strength
At Sub Zero Temperatures ...*

EVEN AT MINUS 300F HANDY & HARMAN SIL-FOS AND EASY-FLO BRAZED JOINTS ARE VERY STRONG



Six-Piece Expansion Valve Assembly For Air Separator Joined In One Operation: Drawing of valve assembly shows locations of 5 preplaced rings of EASY-FLO 3 and EASY-FLO 45.



The need for strong, tight joints for ultra cold service—in rocketry, cold treating and refrigeration of all types—becomes more and more critical.

Recent low temperature tests with Handy & Harman's silver brazing alloys SIL-FOS and EASY-FLO on deoxidized copper lap joints show impressive joint strength.

At minus 321°F, the joint strength (in psi) of EASY-FLO 45 is 30,100 lbs. At the same temperature, the psi of a SIL-FOS brazed joint is 21,900 lbs. These strengths represent the average of four tests with each alloy; HANDY FLUX was used in each test.

A current "sub-zero" example is Air Products, Inc., Allentown, Penn. This company makes an air separator which produces tonnage quantities of oxygen and/or nitrogen for industrial use. The separator's components consist of Type 304 stainless steel, cast bronze, brass, copper, copper bronze and Carboloy. Joint sizes range from less than 1/4 inch to 54 inches in diameter. In operation the separator is exposed to temperatures of minus 300°F and pressures approaching 5000 psi. To join this complex assembly, Air Products uses Handy & Harman's EASY-FLO 35, EASY-FLO 3 and EASY-FLO 45 and HANDY FLUX.

Your NO. 1 Source of Supply and Authority on Brazing Alloys



HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.
DISTRIBUTORS IN PRINCIPAL CITIES

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OAKLAND, CALIF.
TORONTO, CANADA
MONTREAL, CANADA



FOR A GOOD START:
BULLETIN 20

This concise bulletin introduces you to silver alloy brazing—gives joining methods and joint design as well as economies that exist with EASY-FLO brazing. Just ask, we'll be pleased to send you a copy.

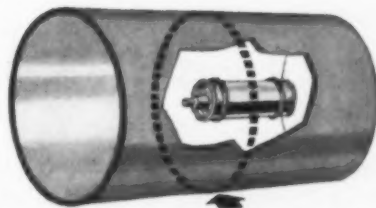


Inspects circles around previous radiographic methods

G-E Resotron 300 with 360° x-ray beam — makes one exposure do the work of 20!

That 24-foot strip of film they're holding represents *one* radiograph of a welded seam circling an American Car and Foundry Division tankcar. With almost 200 feet of welds to be inspected in each tank, full-circle x-ray technics with the G-E Resotron 300 have trimmed inspection costs to a shadow of their former selves. Moreover, exposure speed is $\frac{1}{3}$ faster than any x-ray unit they tried before. And radiographs are better!

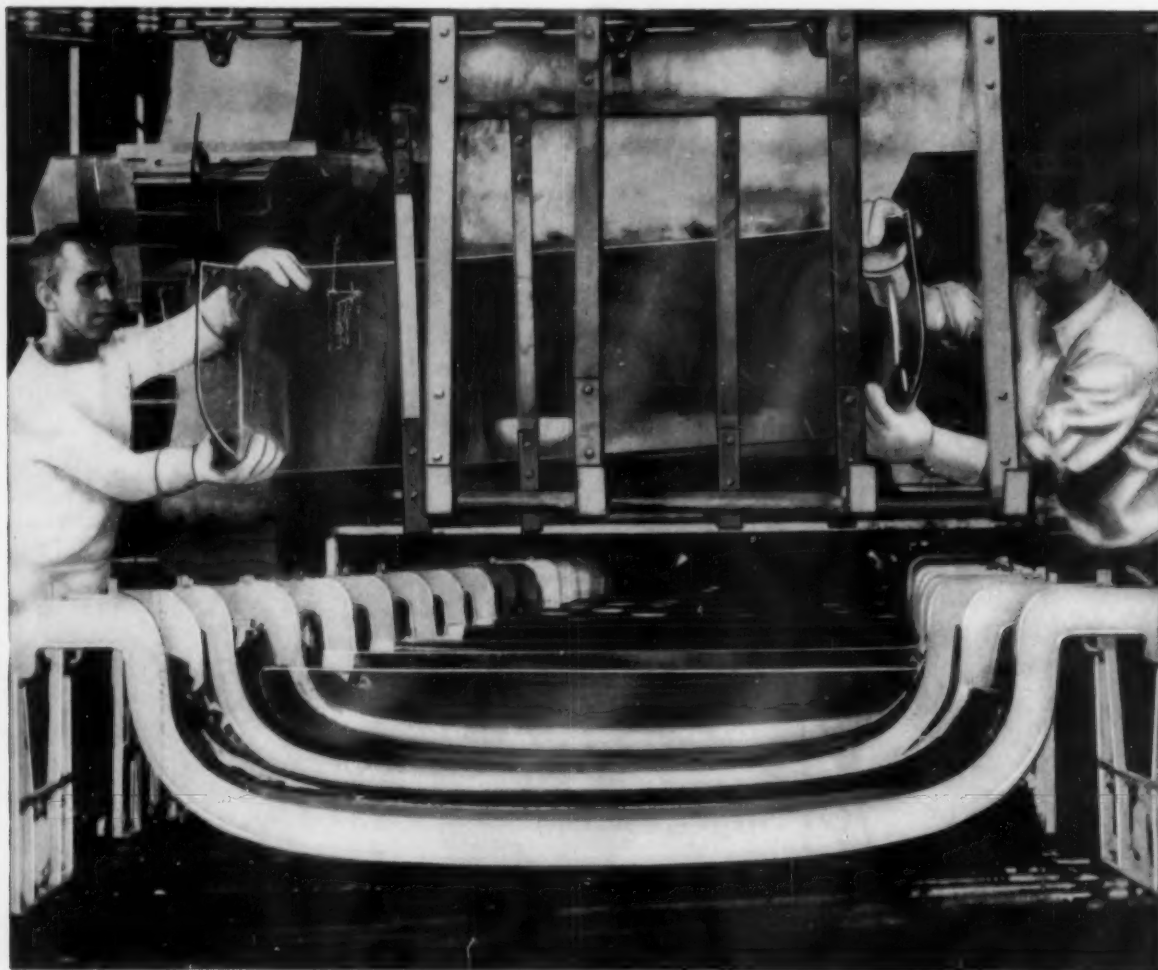
With big developments in x-ray equipment, film and processing, the speed of 100% radiographic inspection has come a long way lately. Your General Electric Representative has all the good news — call him in, or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. AS-94.



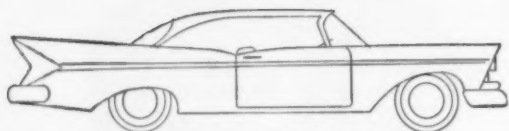
HOW IT'S DONE — At the ACF Milton (Pa.) plant, General Electric Resotron 300 with 360° x-ray tube is positioned in center of tank to inspect circumferential welds with one exposure. It used to take 232 radiographs — each 13 inches long — to get the complete picture.

Progress Is Our Most Important Product

GENERAL  ELECTRIC



Greater visibility, trimmer lines **in new car styling...** **thanks to GAS**



With nearly 7,000,000 cars being produced annually, the increased use of glass has demanded major production improvements in the manufacture of new panoramic windshields and back-lights.

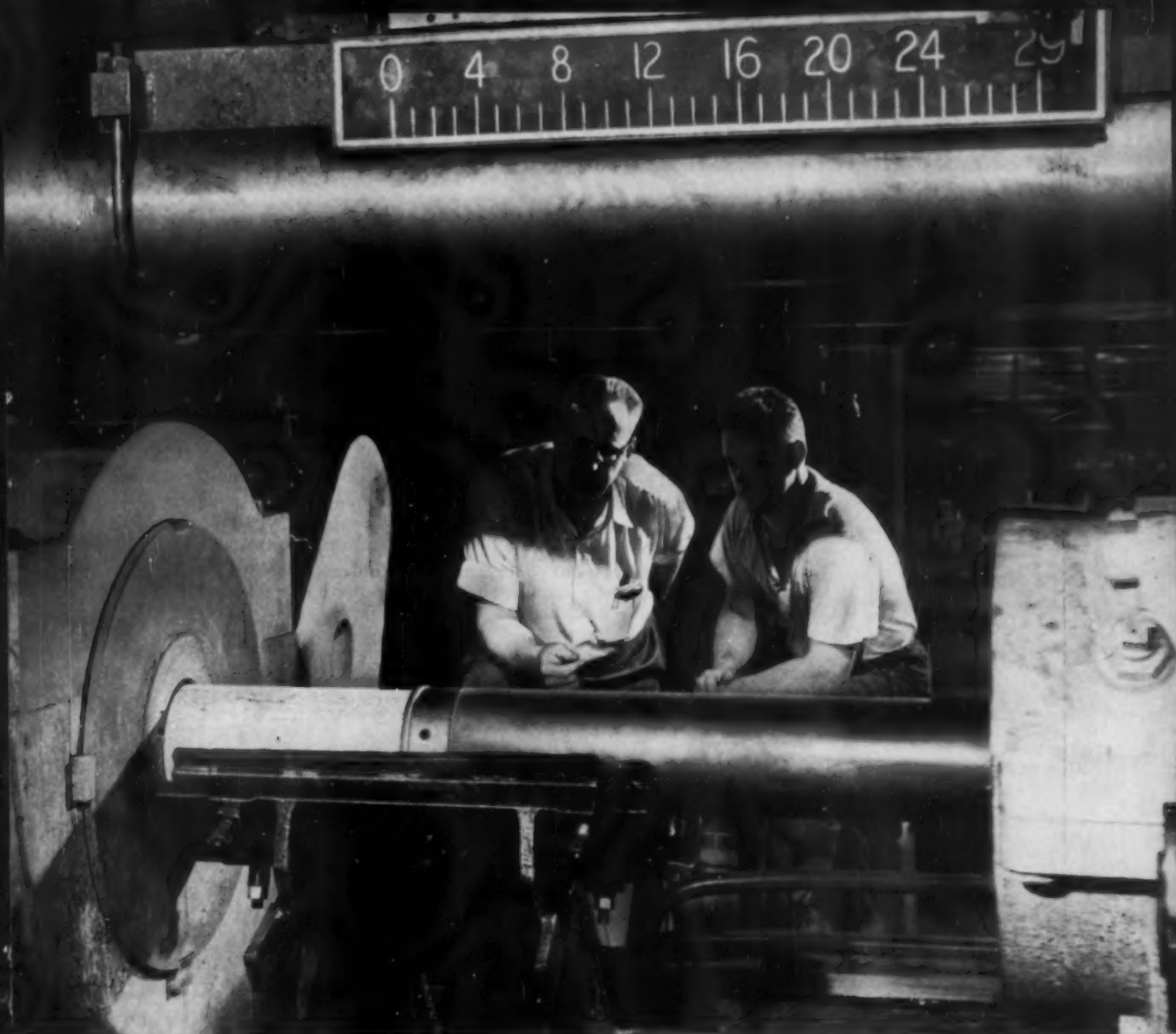
Since the forming of the intricately curved glass is done at a temperature at which glass is soft and can be bent, the production process challenged heat process engineers to design new automatic equipment capable of mass producing these large precision glass pieces.

Selas engineers, working with the nation's leading glass manufacturer, discovered that Gas could produce the proper time-temperature cycle demanded by this

process, efficiently, quickly, reliably. The flat glass is conveyed under radiant Gas burners which bring the glass quickly up to bending temperature and allow the shaping of windshields, with reproducible uniformity, at high production rates.

The production of this wrap-around windshield is another example of the contributions modern Gas equipment is making to American manufacturing. If you have an operation demanding precise process heating, call your local Gas Company's Industrial Specialist and discuss the economies and results you, too, can get with modern Gas equipment. *American Gas Association.*

See Playhouse 90 with Julia Meade on CBS-TV. Watch local listings for time and station. Sponsored by your Gas Company and the Gas Industry.



Why ALCAN extrusion ingot "runs" easier...faster...more economically!

How much difference would better quality billet make in your extruding costs and productivity? *A substantial difference . . . if the billet you switch to is ALCAN!*

For you will find that ALCAN billet offers you every fabricating advantage. It pushes easier, faster. It gives you longer die-life . . . less scrap . . . and better quality of finished product. All good reasons why a trial run can prove to you that this is the most economical billet you can use!

From mining to casting—countless checks on quality make ALCAN the finest of all billet products. It is made entirely of clean, primary metal . . . unexcelled in internal structure and surface smoothness . . . and cast to the industry's closest tolerances.

Telephone us today about testing ALCAN billet on your own equipment! We welcome the opportunity to show you the difference it can make in your extruding costs and productivity.

Aluminium Limited

Ingot Specialist...serving

American Aluminum Fabricators—

*In the U. S.—Aluminium Limited Sales, Inc., 630 Fifth Avenue, N.Y. 20, N.Y.
CLEVELAND • CHICAGO • LOS ANGELES • DETROIT • ATLANTA • ST. LOUIS*

Additional distribution (Alcan Foundry Alloys):

**Apex Smelting Company, Chicago, Cleveland, Los Angeles
Charles Batchelder Co., Inc., Botsford, Conn.**



HOW MUCH IS

Faulty Quenching

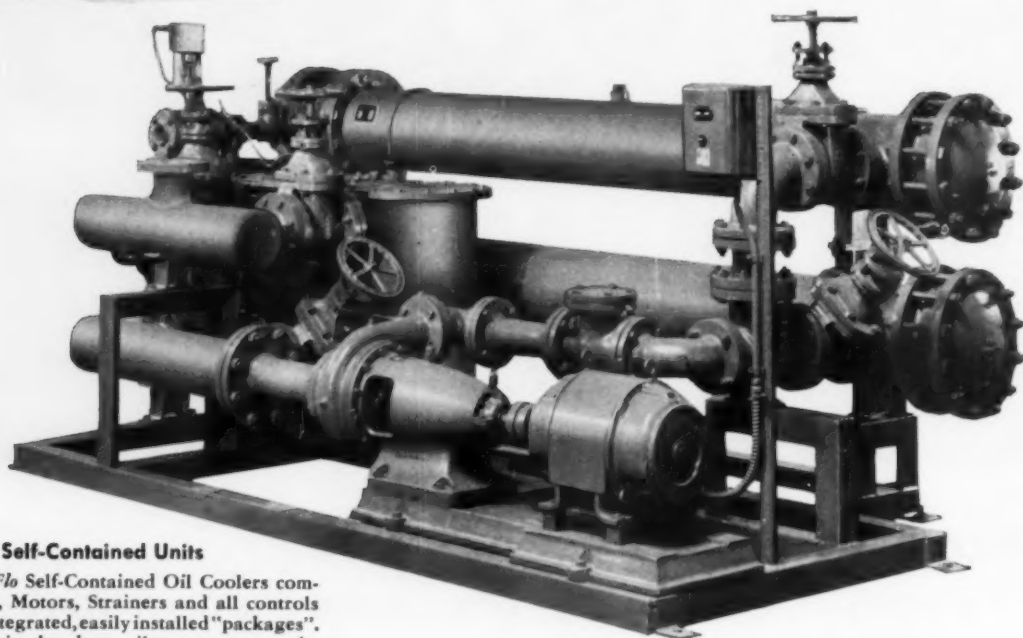
COSTING YOU?

The quenching stage of your heat-treating process is the point which determines . . . (1) the final quality of your product . . . (2) the amount of time and material wasted by below-standard rejects . . . and (3) your ultimate operating costs.

You can protect yourself against needless production losses by installing a B & G Self-Contained *Hydro-Flo* Oil Cooler. This unit will provide the accurate control of conditions in the quench tank which assures *uniform quality* in the finished product.

The generous heat transfer surface in B & G Self-Contained *Hydro-Flo* Oil Coolers provides large capacities in comparatively small, compact units. They are completely factory assembled, ready for immediate installation and operation.

Tell us about your quenching problems—we'll be glad to offer engineering counsel and recommendations.



Completely Self-Contained Units

B&G *Hydro-Flo* Self-Contained Oil Coolers combine Coolers, Motors, Strainers and all controls into single, integrated, easily installed "packages". Fully automatic, they keep oil temperature at the desired degree through all stages of the quench. Your only responsibility is to connect to the quench tank and water lines.

B&G Oil Cooling Systems may also be purchased as component parts for assembly on the job.



This combined Catalog and Selection Manual gives full information on B&G Self-Contained Oil Coolers. Send for your copy.



Reg. U.S. Pat. Off.

Hydro-Flo

OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY
Dept. FW-16, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong Ltd., 1400 O'Connor Drive, Toronto 16

At arctic temperatures and supersonic speeds ... what happens to aircraft skin?



Technicians of Aircraft X-ray Labs, Huntington Park, Calif., radiograph fin of aircraft at -65°F

WITH AIRCRAFT power mounting, with speeds that leave sound behind, extremely high frequency vibrations were bound to build up. What would be their effect on aircraft structures—at temperatures ranging to 65°F below zero? To find out, radiography and Kodak Industrial X-ray Film, Type AA, were put to work.

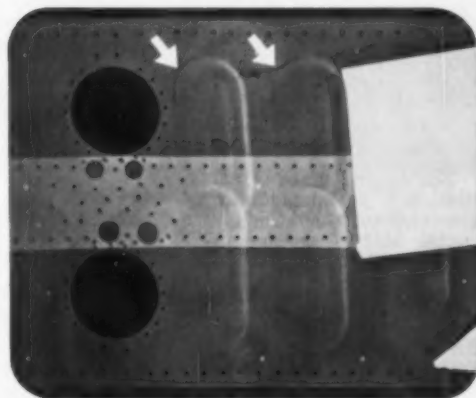
The radiographs revealed fatigue failures and gave clues to the nature of the stresses.

Exposures were made at target distances from 5' to 15' with exposures from 40 sec. to 90 sec. In spite of the cold, the film received no special handling.

All of which shows the importance of radiography as a test—also the dependability and versatility of Type AA Film.

If you build intricate assemblies, make castings or produce welded products, radiography can provide inside information as nothing else can. It can save time and money—improve foundry production and welding operations.

If you would like to know how it can help you, discuss it with your Kodak x-ray dealer—or with the Kodak Technical representative.



Radiograph reveals evidence of material fatigue under stress.

X-ray Division . . . EASTMAN KODAK COMPANY . . . Rochester 4, N. Y.

Read what Kodak Industrial X-ray Film, Type AA, does for you:

- Speeds up radiographic examinations.
- Gives high subject contrast, increased detail and easy readability at all energy ranges.
- Provides excellent uniformity.
- Reduces the possibility of pressure desensitization under shop conditions.

Kodak

The 14th



METALLOGRAPHIC EXHIBIT

Chicago, November 1 to 6, 1959

*All metallographers—
everywhere—
are cordially invited to
display their best work.*

RULES FOR ENTRANTS

Exhibitors do not need to be members of the American Society for Metals.

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable.

Photographic prints should be mounted on stiff cardboard, extending no more than 3 in. beyond edge of print in any direction; maximum dimensions 14 by 18 in. (35 by 45 cm.). Heavy, solid frames are unacceptable.

Entries should carry a label on the face of the mount giving:

Classification of entry.

Material, etchant, magnification.

Any special information as desired.

The name, company affiliation and postal address of the exhibitor should be placed on the back of the mount together with a request for return of the exhibit if so desired.

Entrants living outside the United States should send their micros by first-class letter mail endorsed "Photo for Exhibition—May Be Opened for Customs Inspection".

Exhibits must be delivered before Oct. 15, 1959, either by prepaid express, registered parcel post or first-class letter mail, addressed:

Metallographic Exhibit
American Society for Metals
53 W. Jackson Blvd.
Chicago 4, Ill., U.S.A.

CLASSIFICATION OF MICROS

Class 1. Cast irons and steels.

Class 2. Carbon and alloy steels (wrought).

Class 3. Stainless steels and heat resisting alloys.

Class 4. Aluminum, magnesium, beryllium, titanium and their alloys.

Class 5. Copper, nickel, zinc, lead and their alloys.

Class 6. Uranium, plutonium, thorium, zirconium and reactor fuel and control elements.

Class 7. Metals and alloys not otherwise classified.

Class 8. Series showing transitions or changes during processing.

Class 9. Welds and other joining methods.

Class 10. Surface coatings and surface phenomena.

Class 11. Slags, inclusions, refractories, cermets and aggregates.

Class 12. Electron micrographs.

Class 13. Results by unconventional techniques.

Class 14. Color prints in any of the above classes. (No transparencies accepted.)

AWARDS AND OTHER INFORMATION

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which in the opinion of the judges closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of \$500 from the Adolph I. Buehler Endowment will also be awarded the exhibitor whose work is judged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's national headquarters.

All prize-winning photographs will be retained by the Society for one year and placed in a traveling exhibit to the various Chapters.

41st NATIONAL METAL CONGRESS & EXPOSITION

INTERNATIONAL AUDITORIUM — — — CHICAGO — — — NOV. 1 to 6, 1959



Education in High Gear

Knowledge is the destination of this vehicle — the world's first Mobile Laboratory for Automotive Research and Education.

J&L stainless steel is used exclusively for exterior and interior components to help assure long, useful life. Part of that life will be devoted to gaining a better understanding of how stainless steel combats corrosion, provides greater structural strength, reduces weight, improves performance.

This unique Mobile Laboratory was presented to the University of Michigan by The International Nickel Company. It was adapted from a 27-foot General Motors Coach by Ionia Manufacturing Div., The Mitchell-Bentley Corp. Contributing companies include: General Motors Corp.—Styling Staff, Engineering Staff, Proving Grounds, Truck and Coach Div., Harrison Radiator Div., and Frigidaire Div.; United States Rubber Company; Lyon, Inc.; and Friez Instrument Div., Bendix Aviation Corp.

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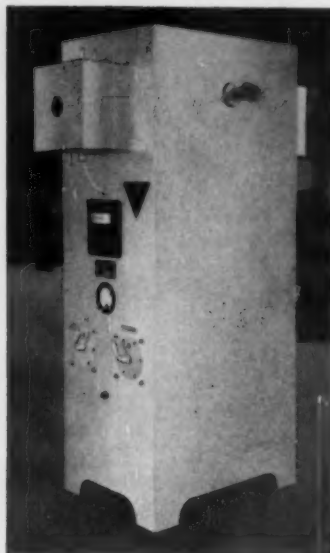


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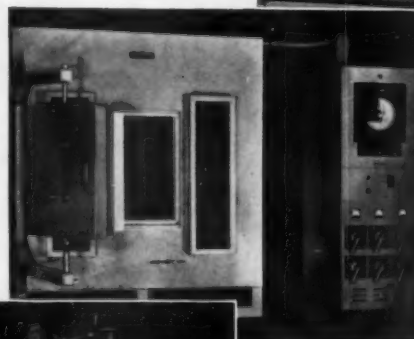
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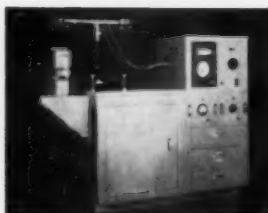
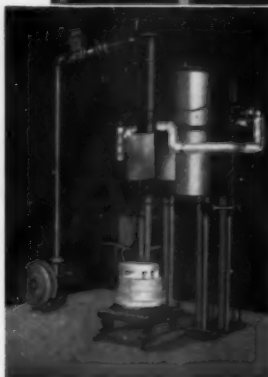
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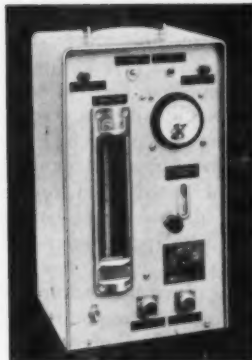


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Behind the By-lines

D. J. Schmatz, J. C. Shyne and V. F. Zackey, who discuss the new "Ausform" process for improving steel by austenitic cold working on p. 66 of this issue, report that the most common question asked about this process is, "How can it be used in automobiles?"—a natural question, since this process was developed at Ford Motor Co.'s Scientific Laboratory. While not usually concerned with specific applications of metallurgical products, the three authors have spent some pleasant hours cooking up an "indestructible" automobile, fabricated from Aus-formed ultra-high-strength steel—ideal for rush-hour traffic, beginning drivers and wives with fender-scraping tendencies.

Dr. Zackey, as supervisor of the physical metallurgy section, has the administrative and research responsibilities for both basic and long-range applied programs. His research activity encompasses varied fields including studies in thermodynamics and phase transformation. Dr. Shyne, an experimental physical metallurgist, has been engaged on research in the development of ultra-high-strength steels and studies on strain aging characteristics of steels. Mr. Schmatz, the most recent addition of the three to Ford's laboratory, joined the company with a background in phase deformation and diffusion in steels and alloys.



Clark E. Quinn, whose work on the Laminagage for nondestructive testing of metals using eddy currents resulted in the article on p. 70, is pictured below with Joe Felice in the General Motors Research Laboratories mulling over a problem connected with the recently publicized G.M. Highway Information System—an electronic communication system to improve highway safety. Called the Hy-Com, the system will transmit traffic bulletins to automobiles moving along the highway within its range. A transmitter operating at short range (a distance of some 100 ft.—enough for a four-lane highway) will transmit messages to a receiver con-

C. E. Quinn (right) in the G.M. research laboratory



nected to a standard car radio. According to Mr. Quinn, the system can serve varied purposes — from warning of hazardous road conditions ahead to announcing the next service station.

In the 17 years he has been associated with General Motors Research Laboratories, designing and developing special electrical and electronic circuitry and instrumentation, Mr. Quinn has worked on a number of important projects, including development of the Sonigage, the electrical system for Firebirds 1 and 2, and many, many others.



H. W. Schultze (author of the article on vapor-phase plating on p. 74), originally a teacher of analytical and general chemistry at Rensselaer Polytechnic Institute, moved into industry to satisfy his desire to probe the practical side of the new technologies being developed. Since joining Climax Molybdenum Co. in 1956, he has been conducting research to find new applications for molybdenum and tungsten compounds, and through his work on vapor-phase deposition, was instrumental in making some of these products readily available. He describes the possibilities for molybdenum and tungsten chemicals as "virtually unlimited and a great challenge to uncover".



Harry Jackson's avid interest in golf may be just one of the reasons why *Metal Progress* is publishing this month (p. 89) the last article of a three-part series on forging, written by Dr. Jackson and his Battelle colleague, Harry Goodwin. The articles are an expansion of a talk he presented before the 1958 annual meeting of the Drop Forging Association, and the meeting was held, coincidentally, just an iron shot away from the championship golf course at the Homestead in Hot Springs, Va.

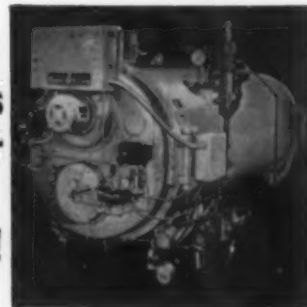
However, Dr. Jackson's reputation as a golfer is even surpassed by his reputation as an expert on research on metalworking and metallurgical problems. With Harry Goodwin's able collaboration, the resultant three articles have provided our readers with a survey of forging in the past, present and its role in the future.

Both Dr. Jackson and Mr. Goodwin are vitally concerned with the entire spectrum of work being done in the Battelle laboratories (currently some 270 projects) but they have retained a few special interests from their laboratory bench days. Some of Harry Jackson's particular interests are foundry practice, titanium alloys and stainless steel, while Harry Goodwin follows the developments in refractory metals, high-purity metals, brittle fracture and metal fibers.



The comprehensive report on oxygen in steelmaking on p. 101 was compiled by E. C. (Chet) Wright after a 14-day tour of steelmaking plants in the United States and Canada. The result, after a thorough sifting of all the facts he'd collected, was the leadoff article of our section on Steelmaking on the Move — a pertinent report giving a survey of oxygen steelmaking. Chet, a consulting editor for *Metal Progress*, is head of the department of metallurgical engineering at the University of Alabama, but before his teaching days, he was assistant to the president of the National Tube Div. of U. S. Steel Corp.

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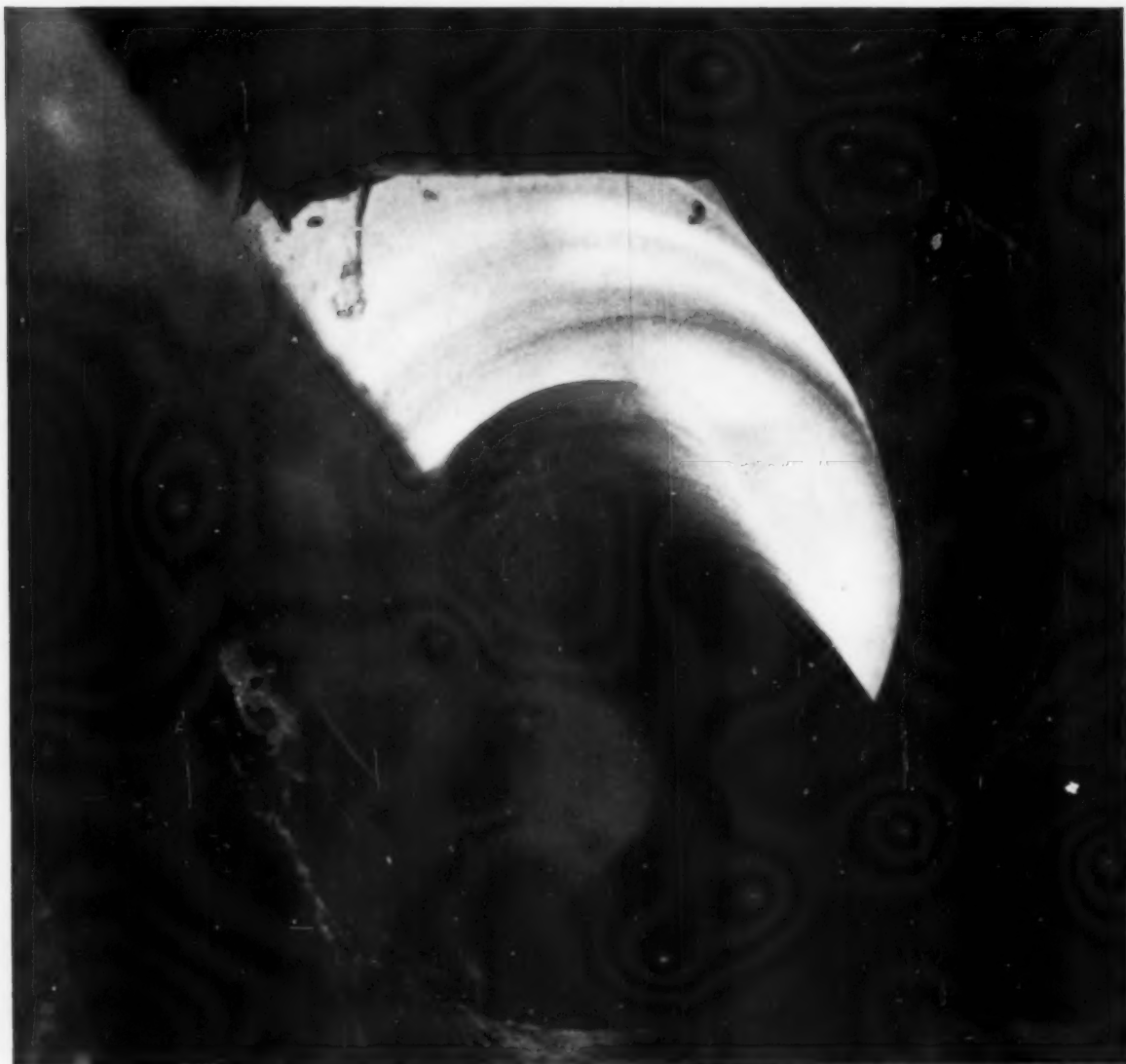
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